Farmer's Irrigation Guide

United States Department of the Interior, Bureau of Reclamation

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Farmer's Irrigation Guide

Conservation Bulletin No. 2

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United States Department of the Interior
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Foreword

Water stored in snowbanks near the tops of towering mountain ranges or backed up behind dams on rivers and streams is the lifeblood of western agriculture.

Its use is an exact science. Properly handled, irrigation water is one of the best forms of crop insurance in the world. Improperly used, it can be as destructive as a sudden flood or a searing drought.

It is with this thought in mind that this booklet was prepared. It represents a blueprint of the best irrigation practices gleaned from years of experience in the reclaiming of arid western lands. Careful reading will net solid dividends for the water user, should he be a small home gardener, an operator on a private irrigation project, or a farmer on one of the numerous Bureau of Reclamation facilities.

Michael W. Straus

MICHAEL W. STRAUS, *Commissioner.*

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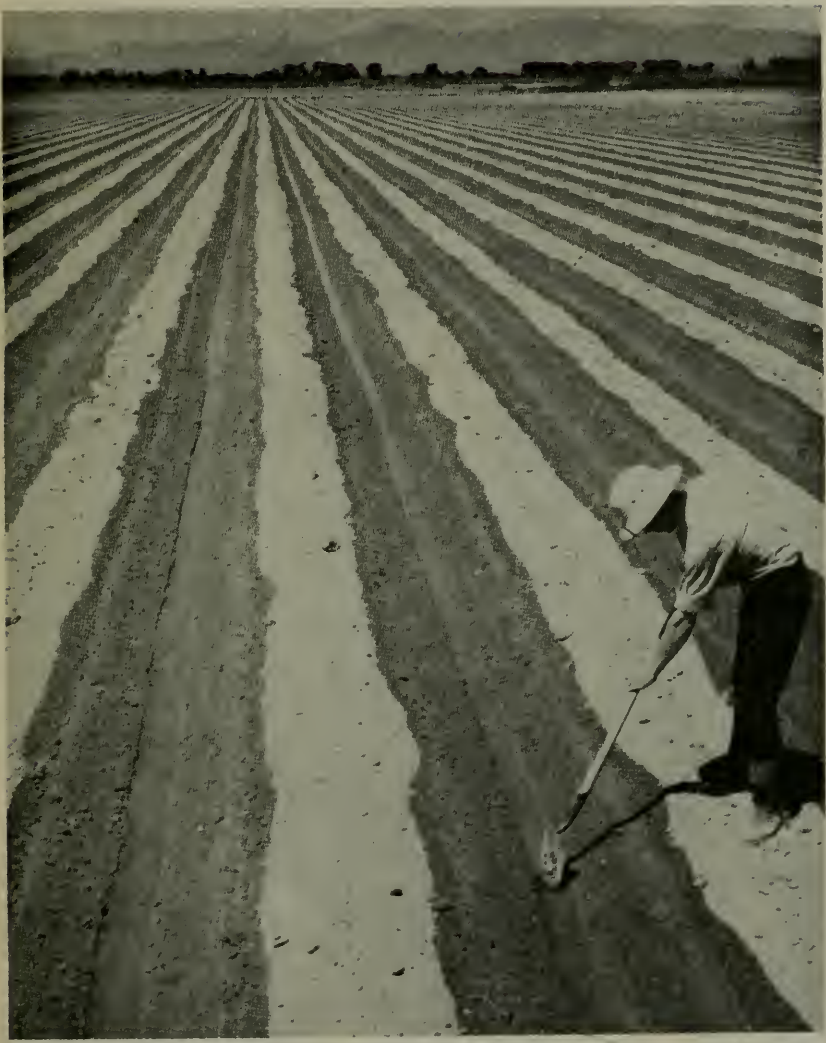


Figure 1.—*What is wrong with this picture? See Page 19.*

Figure 2.—*Examining the soil.*

I. EXAMINING YOUR SOIL

Knowledge of the soil conditions on his farm is of first importance to the grower of crops under irrigation.

The picture opposite (fig. 2) shows a young man examining an excavated cross section of soil. Any farmer can make this excavation to find out his subsurface soil conditions. All he has to do is to dig a hole.

The young man's right hand points to the plow sole. This thin, compacted layer of soil is very important. It comes from plowing at the same depth year after year. Even though only an inch or two thick it often becomes semi-impervious—a barrier to air, water, and plant roots. One way of avoiding its formation is to plow at different depths. Another is to grow plants like alfalfa or sweetclover whose deep roots penetrate the plow sole and keep the soil open. A third is to rotate crops.

Just above the plow sole is the plow slice with which most farmers are familiar. You will notice that this layer, about 7 inches thick (almost 6 divisions on the engineer's tape measure, in which a foot is divided in 10 equal parts) is the darkest. It contains the humus so necessary to plant growth.

Below the plow sole appears a zone of dark grey noncalcareous or limeless clay almost impervious to water. It is lighter in color than the plow slice, you will notice, but not so light as the very compact calcareous layer about 13 inches thick below it, at the end of the tape.

The young man's left hand points to some topsoil which has crumbled and fallen to the bottom of the hole. Its dark color sets it off against the calcareous layer back of it.

You may find other subsurface conditions on your farm. Layers of sand or gravel, for instance, very permeable to water. Your fields may vary too. One field may have ideal soil from the surface many feet down. Another a short distance away may have a floor of hardpan or of shale containing soluble salts or alkali. Still another may have a high-water table too close to the plant roots.

Whatever you find, an examination of the subsoil on your farm will be most valuable to you in determining the right use of your soil and water.

From this do not jump at the conclusion that you cannot get profitable crops if you have a farm with fairly shallow soil floored with impervious hardpan. Many farmers are growing excellent crops on soil less than 3 feet deep. They successfully grow sugar beets and deeper-rooted plants too, like alfalfa.

But shallow or deep, soil must be kept in healthy condition to produce good yields. It must have enough plant food and the proper amount of water from seeding time to harvest.

II. GRADING YOUR FIELD

Uneven land means too much water to some plants and too little to others. Either is bad. Grade your field except where your examination shows porous sand and gravel or hardpan close to the surface. Water spreads evenly only on an even field.

A quick, inexpensive way of loosening the ground to be removed is to use the common spring-tooth harrow. If the ground is too hard for a harrow, plow it.

You can level off the loosened soil with a home-made leveler float, pictured in figure 3. This is a practical, inexpensive device for smoothing land. One man can operate both tractor and leveler. When horses are used the depth-regulating cable or rope can be brought to the driver's platform with pulleys.

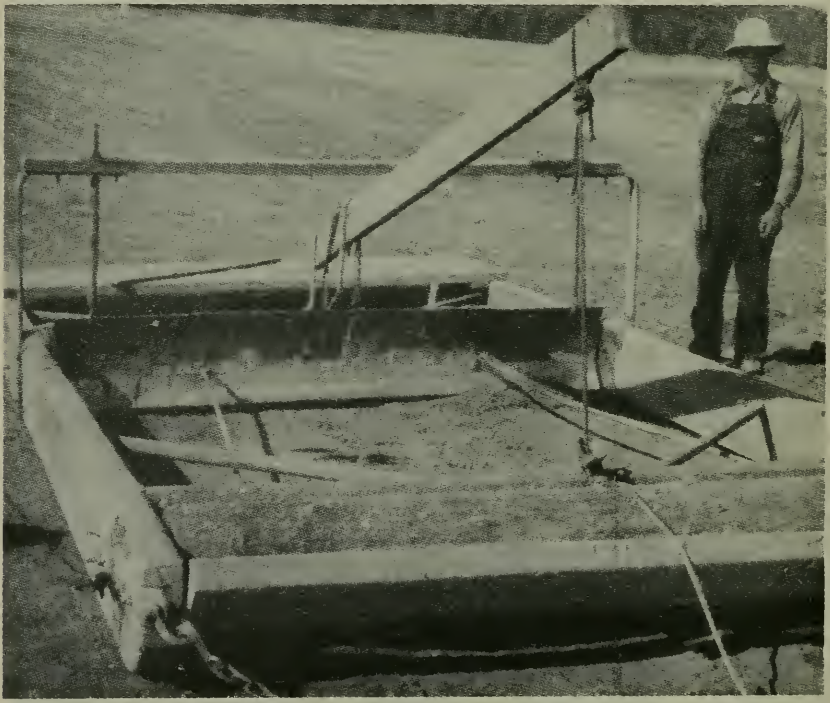


Figure 3.—*A home-made leveler float.*

Rollers in the front and rear lessen the draft and make the leveler easier to pull. They also break hard lumps of earth and pack down the soil.

You can get a drawing showing how to build such a leveler float from any reclamation project or from the Commissioner, Bureau of Reclamation, Washington. D. C.

1. Replacing Removed Plant Food.

Grading the field is bound to remove topsoil which contains the plant foods necessary for plant growth. To grow good crops that food must be replaced.

Use green or barnyard manures and, if necessary, commercial fertilizers to replace such removed food whenever possible. Grow leguminous or nitrogen-rich crops like clover and plow them under. You will thus effectively replace what your grading has removed.

Unless you do this no amount of irrigation can produce good, healthy plants. Soil without the necessary elements for plant growth cannot possibly produce satisfactory crops. Be sure to replace plant food removed by grading before irrigating.

Figure 4 shows a farmer plowing under oats to replenish the soil.

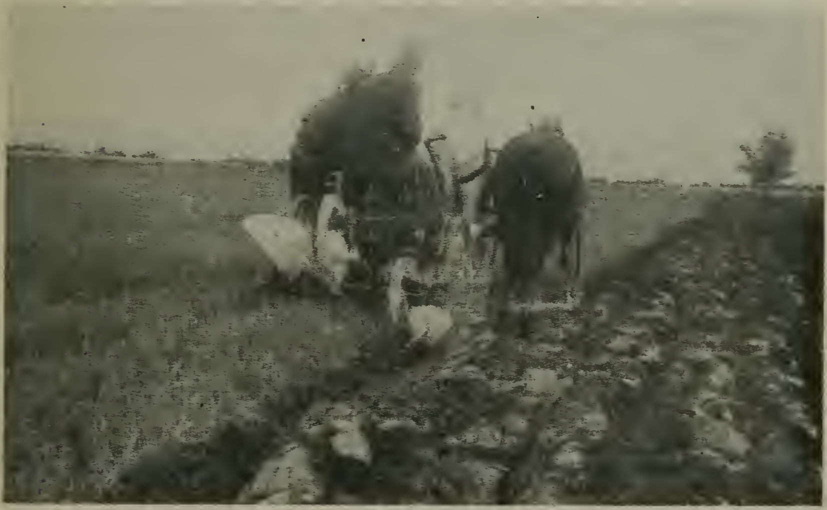


Figure 4.—*Plowing under oats.*

III. IRRIGATING YOUR LAND

1. Systems of Irrigation.

In selecting the method of irrigation best for your farm do not rely on either formula or prevalent practice. Do not adopt a certain system just because others in the community are using it. Consider the ground slope of your fields and the ability of the soil to absorb and hold water. Learn the root zones of your plants and the quantities of water they need. Then use your own good farm sense in choosing the irrigation system best for your particular field or fields.

Irrigators have developed three good methods of easily controlled irrigation: The corrugation or furrow system, the border or flood system, and the ridge or bed system. The choice between them depends on the soil and contour of your field and the kind of crop you want to grow on it.

The corrugation or furrow system is suitable for land too steep or too uneven for the border system and not level enough for the ridge system. You can use it with either large or small streams of irrigating water, which you can run off in as few or as many corrugations or furrows as you wish, according to the size of the stream available. When you have only a small stream of water the corrugation system is particularly suitable.

The border or flood system is fitted for fields that have regular slopes in one direction. The slopes can be as flat as 1 inch in 200 feet or as steep as 1 foot in 100 feet. The border system is well adapted to alfalfa, clover, and other forage crops, and also to small grain. It may be used on any type of soil. When other conditions are favorable it is best for very permeable soils. Therefore, if the contour of your farm permits, and the ground can be leveled, give the border system your consideration.

The third method of irrigation, the ridge or bed system, is suitable where the ground is nearly level and the soil rather shallow. Do not let this statement lead you to believe that the ridge system is unsuitable for other conditions, however. Some of the most highly developed irrigated sections of this country, especially those on flat land, are using the ridge system. In regions where the spring is cold the ridge system of irrigation permits the soil to warm more quickly and bring about earlier seed germination.

You will find both the corrugation and the border systems suitable for small grains, alfalfa, clover, pasture, or other semipermanent crops. Lettuce and sugar-beet growers commonly use the ridge system if the soil and contour of their land permits.

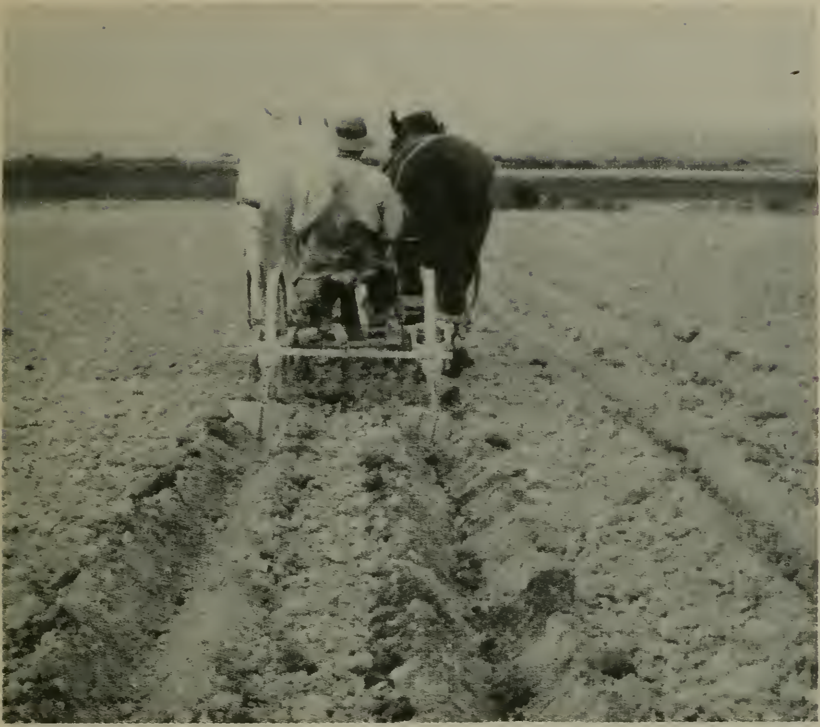


Figure 5.—*Making corrugations with a manufactured shovel corrugator.*

a. The Corrugation System.

The owner of the farm in figure 5 has chosen the corrugation or furrow system to irrigate this field. He is making his corrugations with a manufactured two-row corrugator. The soil on his farm is clay and rather impermeable, and the slope is not too steep, so he is making fairly large ones.

The spacing and size of the corrugations suitable for a certain field or crop is best learned by experimentation. In general, however, corrugations are spaced from 2 to 3 feet, center to center. Principal controlling factors are the composition of your soil, whether sand or clay, the organic matter present in it, the slope of the field, whether steep or flat, and the presence or absence of a plow sole or impervious soil close to the surface.

In general the more porous your soil and the steeper your slope the more closely spaced the corrugations should be, in order to avoid the loss of water and topsoil.

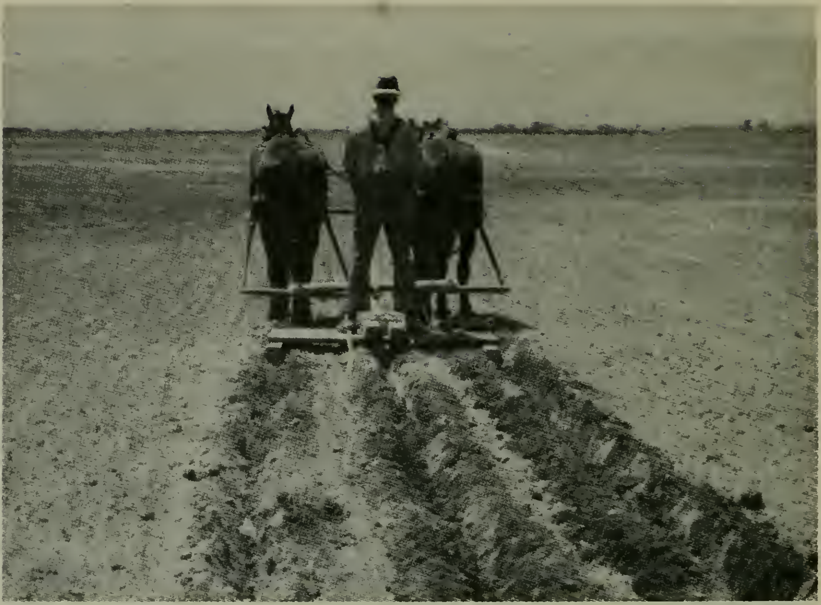


Figure 6.—*Making corrugations with a home-made sled corrugator.*

In figure 6 the farmer is making his corrugations with a homemade device. The soil on his farm was loam, well supplied with organic matter, about 18 inches deep over gravel. In this picture the field appears fairly level, but in reality it has too steep a slope for the border method. The soil was loose, also, and needed packing in the corrugations. The runners will help do this.

The corrugations in the picture are spaced 2 feet, center to center. Here even small streams of water will give the required penetration and lateral spread of water in a few hours without wasting either soil or fertility.

The runners on the home-made corrugator used by this farmer consist of 4 by 6 six-foot timbers rounded on the lower sides. You can build a corrugator like this in less than an hour.

b. The Border System.

The second method of irrigating land is the border or flood system.

To use the border system first divide your land into strips. Make them rectangular if possible and lay them out in the direction of the greatest slope. Then make the borders, or miniature levees, along the sides of the strips. The ground surface of the strips should be as level as possible from side to side. Water applied at the upper part of the strip flows down it.

On steep slopes you should make your borders close together, about 20 feet apart, and use a small head of water. On gentler slopes you can make them farther apart, 100 feet or more, but you must use a larger head of water. A small quantity of water, for example 1 cubic foot a second or less, would not cover enough ground, especially on permeable soil.

If you choose the border system and have decided where the borders might go, first loosen the ground on each side of the border line with either a disk or a spring-tooth harrow. As you can see from figure 7, in which the farmer is using a home-made device for making his borders, the dirt can then be moved easily into straight lines. The depression on each side of the border caused by moving the dirt can be filled in easily with a drag or some similar implement for smoothing land.

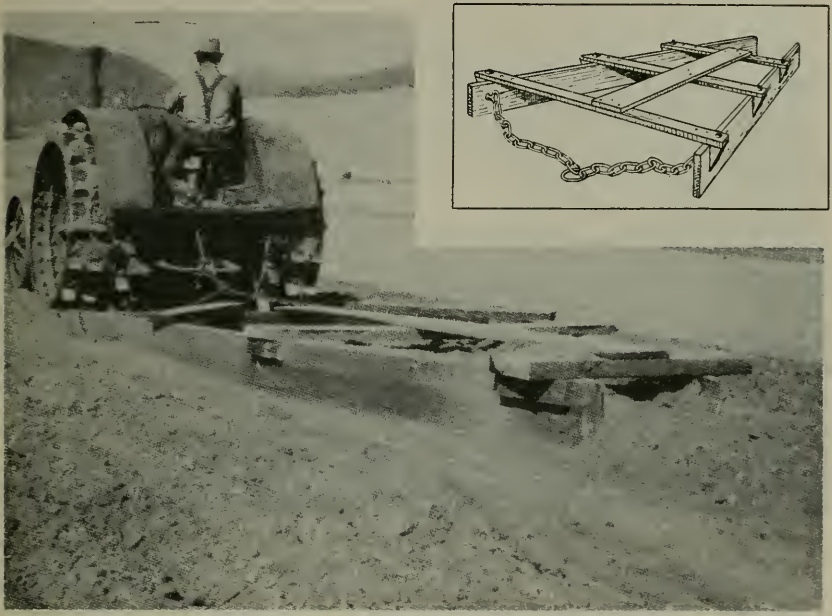


Figure 7.—*Making borders with a "Lazy A." (Inset) Drawing of a "Lazy A."*

Borders should be seeded. Water will spread laterally when irrigating and allow the plants on the borders to do nearly as well as those on the strips. Seeded borders will have no more weeds or insects than the rest of the field.

Borders should only be high enough to prevent water on one strip from flowing to adjoining strips. If you also round them off they will not interfere with mowing, raking, or moving the crop. The home-made device for making borders illustrated in figure 7, is sometimes called a "Lazy A." You can build one in about an hour. The sides consist of 3- by 12-inch planks 12 to 16 feet long. The front and rear openings are 10 and 2 feet wide, respectively. To make it rigid and to keep the sides from spreading, spike 3-inch planks to the top at the front, center, and rear as shown, with 60-penny nails.

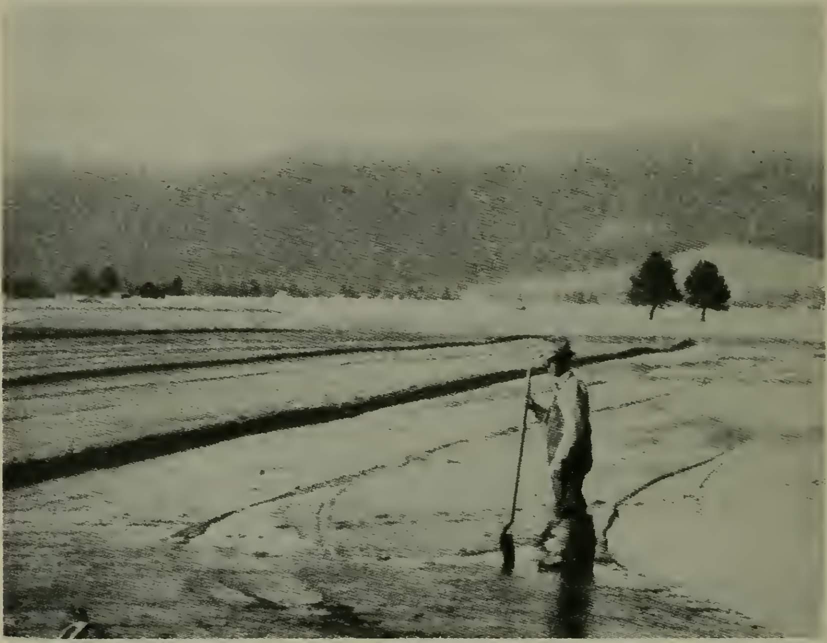


Figure 8.—*Borders completed. Irrigating.*

In figure 8 you can see the same field with the borders completed.

This farmer is irrigating to find out the width of strip best fitted for his field. Where he is standing the borders are 40 feet apart. At the left they are 30 and at the right (not showing) 50 and 60 feet.

This farmer found that with the water available (approximately 2 cubic feet a second) the 40-foot strip provided more uniform penetration with the least amount of water running off at the lower end of the field.

The average slope of this field in the direction of the borders is 3 inches per 100 feet. The borders are 400 feet long.

At the end of this field the ground was too steep for the border system so he used the corrugation system instead by collecting the waste water in a ditch and using this water to irrigate the slope with corrugations. Thus he controlled the movement of the water over the entire field and lost very little soil or water.

At the end of the borders he also ran a secondary head ditch. This enabled him to irrigate the field below the borders whenever he wished without depending upon the waste water from the borders.

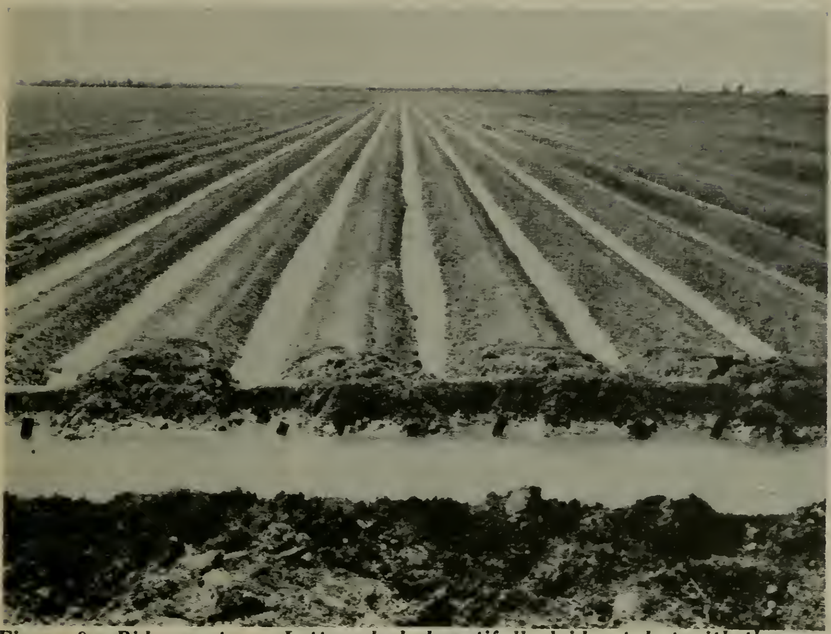


Figure 9.—*Ridge system. Lettuce beds beautifully laid out, but with the same fault illustrated in figure 1. The rows are far too long. See page 19.*

c. The Ridge System.

The third method of irrigating land is the ridge or bed system.

The ridge system of irrigation is comparatively simple to put into operation if you have the land suitable for it. Merely plow your land in straight furrows close enough together to form ridges. The dirt moved by making the furrow elevates the ridge.

Ridges should be prepared in the fall, if possible, and go into the winter damp. Freezing and thawing breaks the clods of earth. This with the natural settling helps make a good seed bed.

The ridge system of irrigation is particularly suitable to farms with tracts of practically level ground.

Figure 9 shows lettuce beds beautifully laid out, using the ridge system. But this farmer's irrigation, like that pictured in figure 1, has a bad flaw. The rows are much too long. They should be broken by secondary head ditches farther down the field, and offset. See page 19, in the section "Controls."

Figure 10 shows the ridge system irrigating sugar beets on a nearly level tract of land. These rows are 625 feet long, but the large furrows between the alternate beet rows make it possible to get the water through to the opposite end even though the ground is nearly level.

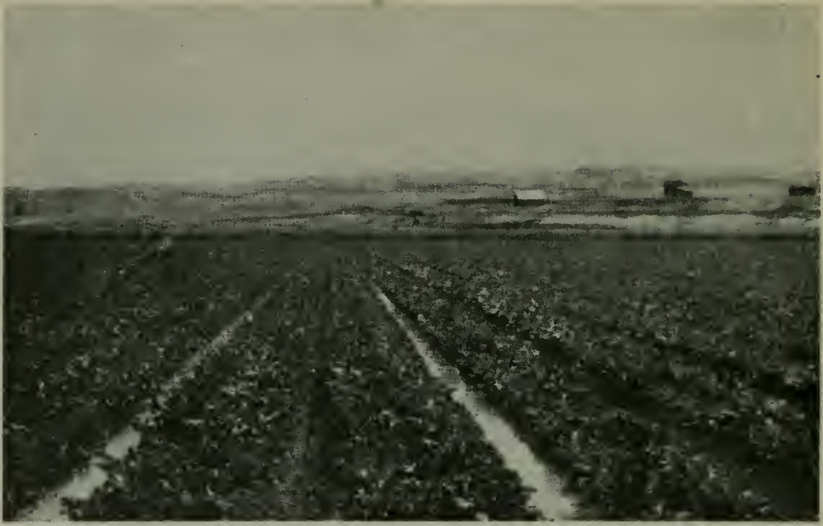


Figure 10.—*Ridge system—sugar beets.*

The diagram in figure 11 shows how the ridges are spaced, their approximate size, and their height.

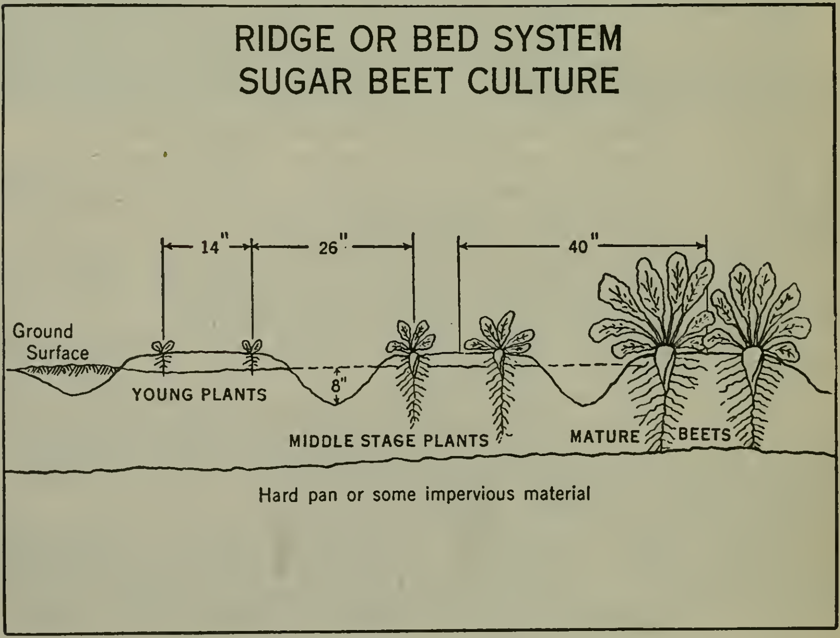


Figure 11.—*Sugar beet culture—ridge system.*

2. Overirrigation.

You have just read about three methods of irrigation which can be used on your farm. Whatever method you choose always bear in mind that good irrigation practice is not just a matter of pouring water into the soil. It should be the right amount of water, neither too little nor too much. Too little water will starve your plants; too much will leach the rich plant food in your soil and even wash away the soil itself. Saturating your field with water is like pouring soluble plant food into the drains.

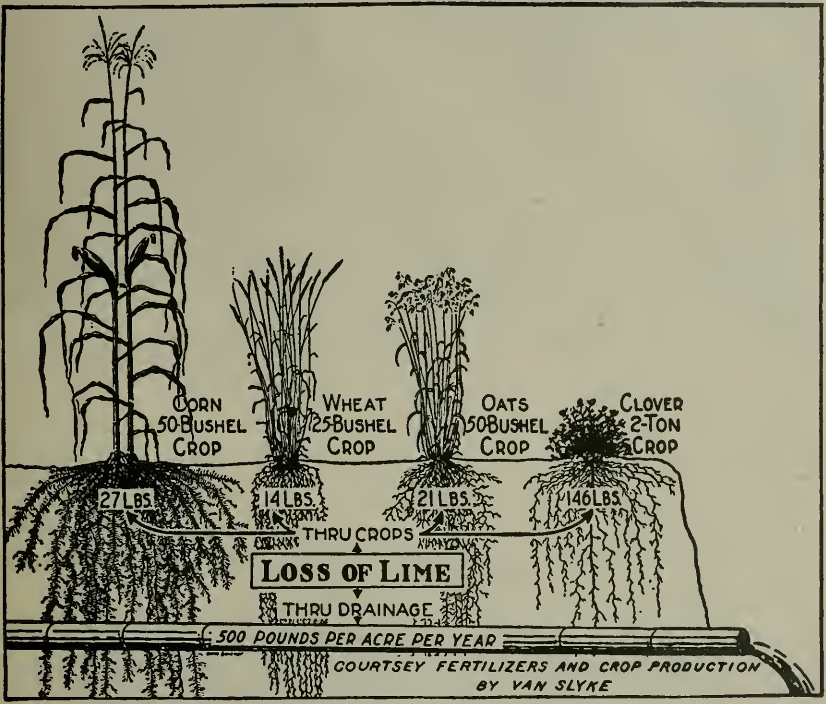


Figure 12.—*Leaching loss.*

Figure 12 compares the soluble plant food taken from the soil by plants, on the one hand, and leaching, on the other. These four crops, corn, oats, wheat, and clover, grown together would use an average of 52 pounds of lime an acre yearly. Heavy rains, however, can leach 500 pounds—10 times as much!

If leaching by heavy rains can take this amount of lime out of your soil it is obvious that overirrigation will have a like effect. The downward percolation of water may be slower in clay soils than in sand or gravel but ultimately overirrigation will take its toll.

Overirrigation is harmful. Avoid it by controlling the amount of water you give to your plants.

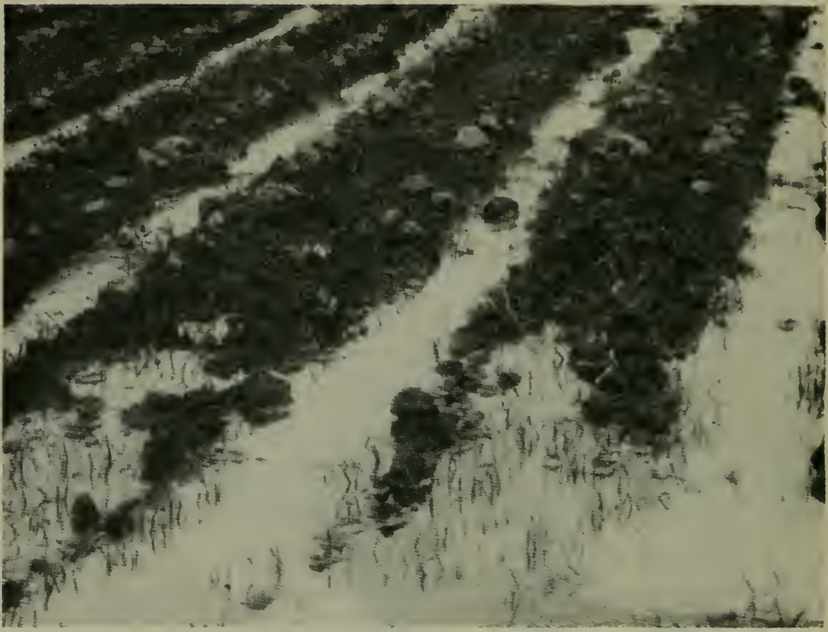


Figure 13.—Overirrigation—*Example No. 1.*

This field of young oats in figure 13 shows distinct overirrigation. This farmer is leaching his soil of the plant food vital to crop growth. Worse than that—the water standing in pools and soaking the ground is damaging and possibly killing his crop.

Very few crops can long remain submerged. They drown. On a warm day the danger is still greater. The heated water can scald them to death in an astonishingly brief time.

But the presence of too much water on the surface of his field is only one of the indications of overirrigation available to the alert farmer. Had this farmer probed or examined his soil before irrigating he could have known beforehand that the soil below the surface was already moist enough for proper plant growth.

Another mistake this farmer made was that after turning on the water in the morning he left the field to do other farm work, returning at night to make another 12-hour set. Stay in your field while you irrigate, and watch the movement of your water.

Figure 14 shows a different example of overirrigation. Too large a head of water has scoured the corrugations. It has cut away the sides and eaten through the plow slice deep into the soil below. It is washing fertile topsoil into the waste ditches, filling them with silt.

This erosion has already increased the cross-section area of the corrugations about 10 square inches. Excessive water in later irrigations will make the corrugations still larger. It will wash more topsoil into the waste ditches.

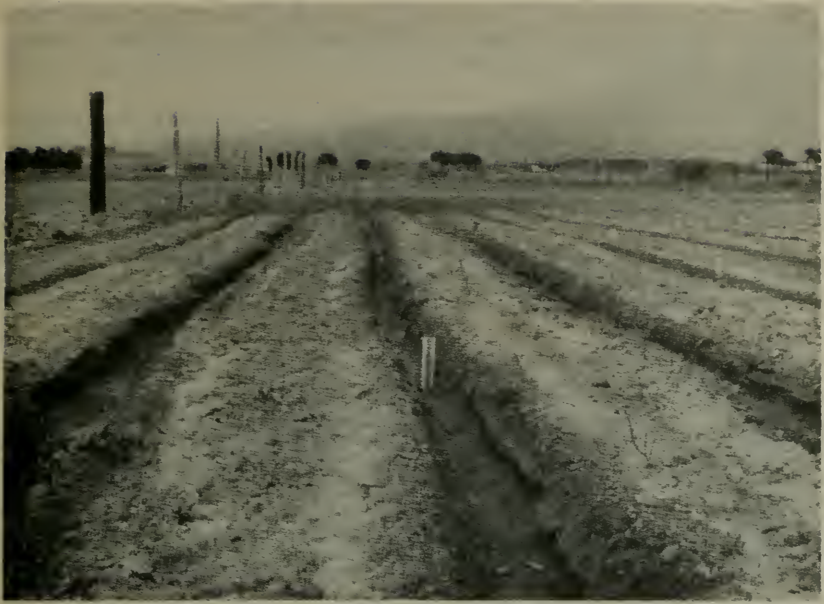


Figure 14.—*Overirrigation—Example No. 2.*

In continuous cropping which requires new corrugations each spring, irrigating with overlarge heads of water can wash away your whole top 6 or 7 inches of topsoil in very few years.

You can prevent this soil erosion by shallower furrows, smaller streams in each furrow, and angling the furrows across the slope (where large furrows are used as for corn and potatoes).

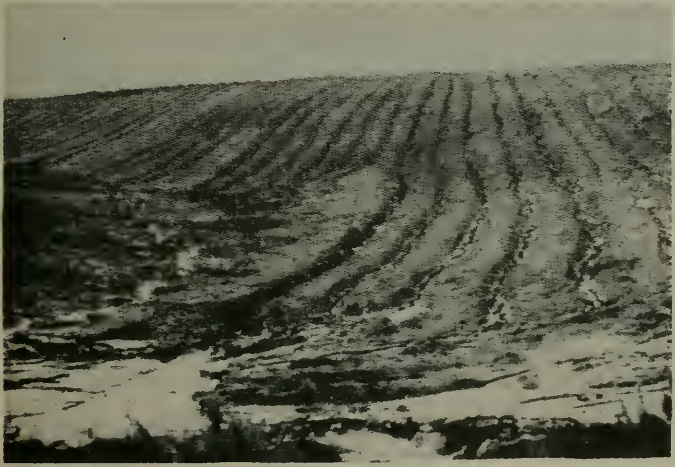


Figure 15.—*Overirrigation—Example No. 3.*

Figure 15 shows a flagrant example of topsoil loss because of lack of water control.

On a steep slope like this one, the run-off from heavy rains—like the application of too much water—will cause considerable soil erosion. Obviously the steeper the slope the greater the care necessary to avoid this erosion.

Where topography permits, running the corrugations on a slower grade will materially slow up the movement of soil with the water.

Using fields with easily eroding soil for hay or pasture instead of cultivated crops is another way of keeping the fertile topsoil on your fields.

Finally, properly spaced contour head ditches on different slopes, thereby cutting the length of runs, would have reduced if not entirely prevented this erosion. They would have controlled the flow of water.

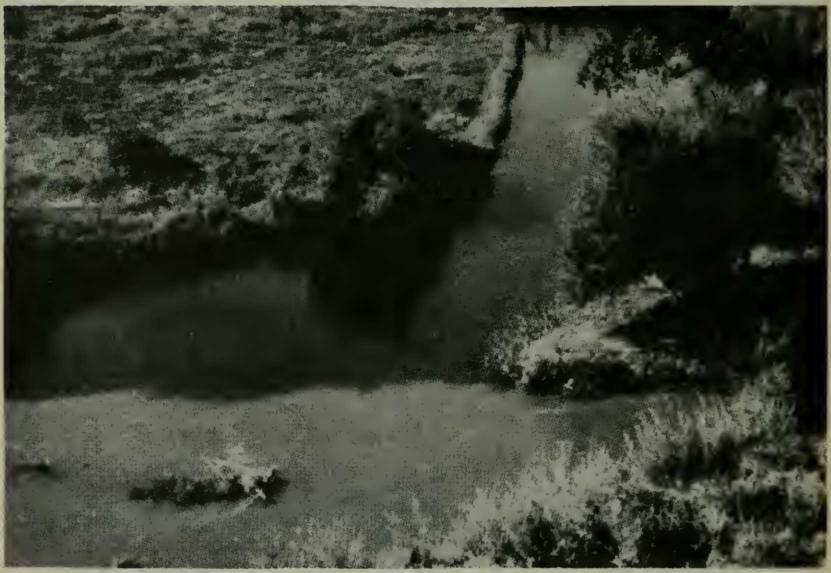


Figure 16.—*Overirrigation—Example No. 4.*

Surface waste water filled with silt enters a stream of clear water in figure 16. That dark upper part of the stream in the picture is clear water but that in the immediate foreground, entering from the right, is actually coffee-colored, it is so full of silt. This silty water is from fields whose topsoil is washing away—and the farmer's income, too.

Farmers are more or less aware of the soil losses from gullying, but the soil creep which comes from uncontrolled water when irrigating is a thief in the dark. Control of your water flow will stop that thief.

3. Controls.

Use controls to avoid soil erosion, water wastage, and leaching, when irrigating your farm. Use head ditches, dams, spiles (small wooden tubes) and equalizing basins to distribute and regulate the flow of water.

Lead your water from the lateral or branch canal into a head ditch at the top of your field. This gives you initial control over its flow. Then dam the ditch wherever necessary and distribute the water to your corrugations through spiles.

An equalizing basin between the head ditch and the spiles will give you additional control, as will secondary head ditches farther down your field.

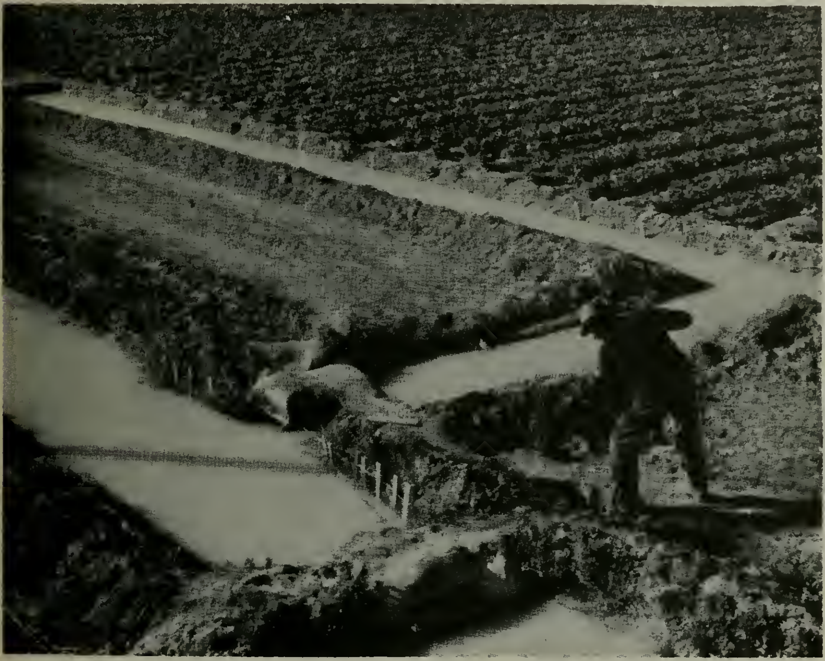


Figure 17.—*Head ditch, dams, equalizing basin, and spiles.*

Figure 17 shows a farmer in a field of irrigated lettuce. He has led the water from the canal into the head ditch on his left. Here he has dammed it with earth-filled sacks. On his right, paralleling the head ditch, runs an equalizing basin, also dammed, and he faces still another dam which checks and drops the water from his head ditch to his equalizing basin, which in turn finally delivers the water to the corrugations through the spiles.

An equalizing basin distributes the water and maintains its steady flow. It should be as small as possible to use the least land and avoid the loss of water through evaporation and seepage. Equalizing basins are not essential to good irrigation control, but they help. And also, if you wanted to, you could lead the water directly from your head ditch into the corrugations by using gravel or weeds as chokes, but you would have to stand constant watch to keep the water from eroding some openings and overloading one furrow while drying up another.

The best way of delivering water to your corrugations from either head ditch or equalizing basin, if you use one, is through spiles. These small wooden tubes feed an equal amount of water to every corrugation.

In the picture, if you will look again, you can see regularly spaced stakes sticking out of the far side of the equalizing basin. These stakes are slats which cover the spile openings to prevent the water from flowing through the spiles into the corrugations. This farmer will merely pull out the slats when he wishes to irrigate his lettuce. The spiles will deliver an equal amount of water to every corrugation. He can distribute and regulate the flow of his irrigation water at will. He wastes neither soil nor water.

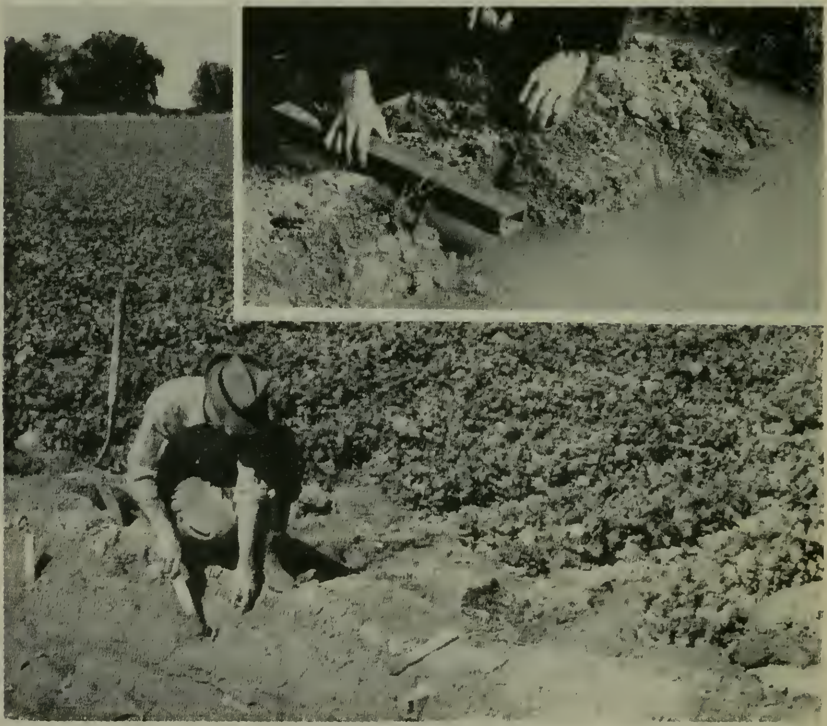


Figure 18.—*Spile openings. (Inset) Placing spile.*

In Figure 18 we have dammed off the equalizing basin to show the spile openings. The inset, upper right, shows a spile being put in place.

Spiles are effective, inexpensive controls. You can nail 4-foot laths side to edge and cut them in half and make two spiles long enough to extend through most head ditch banks. You can remove them after your last irrigation and use them again every season as long as they last.

Have your head ditch or equalizing basin full of water (as in the inset) when placing your spiles. Then if you place them just below the surface of the water you will be sure to get them level. They will distribute equal amounts of water despite possible different drops to the corrugations on the other side of the ditch bank because of field slope.

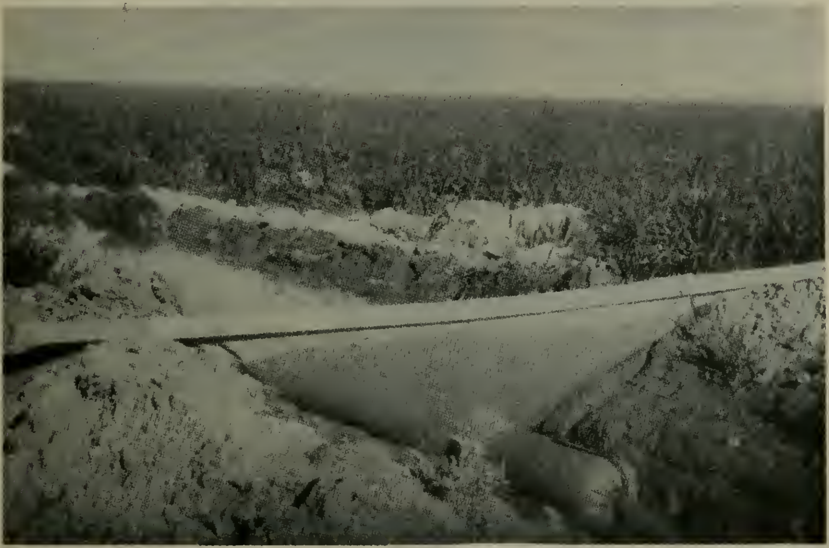


Figure 19.—*Sleeve-type canvas dam.*

A better and more efficient dam than the earth-filled sacks previously portrayed is the sleeve-type canvas dam illustrated in figure 19. It is 4 by 6 feet, about the right size for most head ditches, and costs about $3. If cleaned, dried, and placed under cover after the last irrigation it will last many seasons.

The sleeve in the center is about a foot in diameter. Untying the cord at the outlet end of the sleeve increases the flow of water. Pulling on the ends of the cord and then tying them decreases it. In this picture the opening is nearly closed.

The sleeve-type dam is very effective where relatively small heads of water, about 3 cubic-feet a second or less, should be used because of the composition of the soil and contour of the field.

When the head ditch is on a steep slope it is good practice to control the water with additional sleeve-type canvas dams.

The wooden box head ditch shown in figure 20 brings water to corrugations in a field too steep for a regular earthen ditch. The slope is 4 feet in 100 feet.

Wooden box ditches like this one can be built cheaply of low-grade lumber. They are very practical and more permanent than earthen ditches. No matter how fast its flow, water in box ditches cannot wash away topsoil. They use less land than earthen ditches, too.

This wooden box ditch is three-sided and consists of 1- by 8-inch boards. The size of the box is gradually reduced toward the bottom of the field.

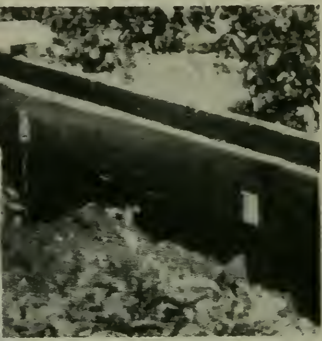


Figure 20.—(*Right*) *Box-type ditch.*

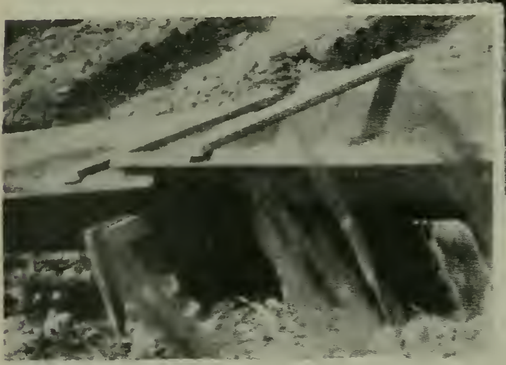


Figure 21.—(*Left*) *Trough-type ditch.*

In the side of the box you can see two white squares, one closed and the other partly opened, letting out a tiny stream of water into the corrugation. These white squares are metal slide gates which cover 1-inch holes bored in the box. They let out just as much or as little water as you wish. A piece of lath nailed just above each hole will also do this, but less efficiently.

A simpler form of wooden head ditch, the V-shaped trough, is especially suited to very steep ground. It is effective on slopes even steeper than 4 feet in 100. Each section consists of two boards nailed together and braced across the top. The sections overlap each other down the slope. Old sacking will lessen leakage at the overlapping joints.

Figure 21 shows one section overlapping the other and how they are held in place by a cradle made of 1-inch board. Notice the bracing crosspieces on top. Use three for each section, one at each end and in the middle.

V-shaped trough ditches are easy to make, easy to place, and easily removed at the end of the season. If you store them away under cover and give them reasonable care, they will last many seasons.

You may find that a single head ditch does not give you proper water control. You may find secondary head ditches necessary.

DIAGRAM SHOWING WASTE OF WATER WHEN TOO FEW HEAD DITCHES ARE USED

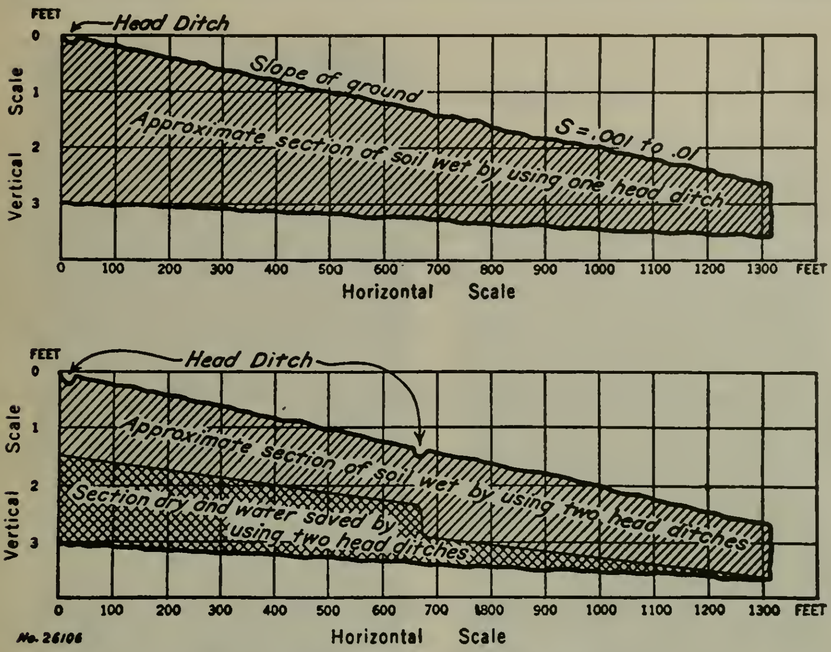


Figure 22.—*Saving water, soil, and plant food.*

The top chart in figure 22 represents a field a quarter of a mile long with one head ditch at the upper portion of the field. In order to get enough water penetration at the lower end of the field an excessive amount was necessary at the upper end. As a consequence the water is penetrating far below the depth required for plant growth. The farmer is wasting his water and the water is leaching his soil.

The bottom chart in figure 22 shows the same field with two head ditches. The secondary head ditch has its own dam system, collects waste water from the first part of the field and redistributes it to the next part. You have the required penetration for growing crops over the entire field with no places where water is sinking deeply enough into the soil to cause seepage and waste.

The lettuce fields pictured in figures 1 and 9 are irrigated from only one head ditch, yet the rows are a quarter of a mile long. This farmer would have to leach his soil and also waste his water at the upper part of his field in order to get enough water down to the lower part. He should have used secondary head ditches.

The same rule—more than one head ditch where necessary—holds true on steep ground, too. Water able to reach the ends of very long rows would have to flow fast; it would wash down valuable topsoil.

IV. DETERMINING THE MOISTURE

1. Use of the Probe

When a farmer applies water by irrigation he should have some quick way of determining the amount of moisture in his soil.

A moisture probe is a simple tool that can be used when irrigating to find out where water has penetrated. It can keep the farmer in close touch with the moisture condition of his soil throughout the growing season.

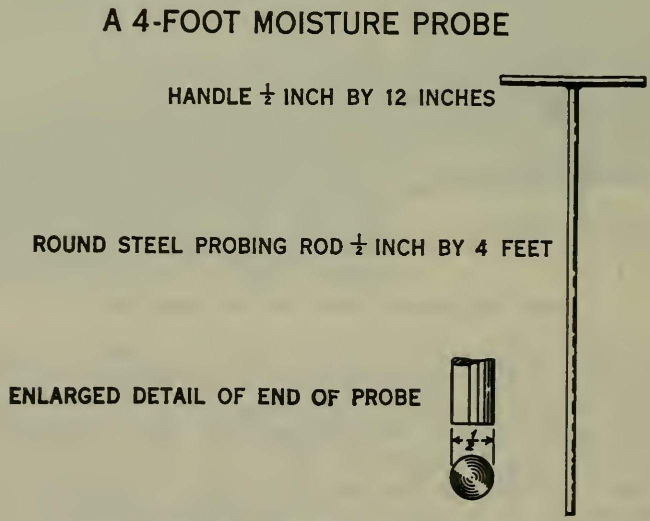

A 4-FOOT MOISTURE PROBE
HANDLE ½ INCH BY 12 INCHES
ROUND STEEL PROBING ROD ½ INCH BY 4 FEET
ENLARGED DETAIL OF END OF PROBE
½

Figure 23.—*T-square moisture probe.*

The drawing above in figure 23 shows a moisture probe—a round steel rod 4 feet long and one-half inch in diameter, with a **T**-handle. The tip of the rod is blunt. You can make one like it for about 40 cents.

The ease with which soils can be penetrated or probed depends upon their structure and amount of moisture.

In figure 24 the farmer pushed the moisture probe with little effort through the plow slice (the dark part just below the man's feet) because the soil was moderately moist. Had it been wet, the probe could have been pushed through with even less effort.

The farmer had to use more pressure to push the probe through the plow sole—that lighter layer of soil directly below the plow slice, at the figure 4 on the engineer's tape measure. Plowing at the same depth year after year and not diversifying crops formed this hard-packed layer.

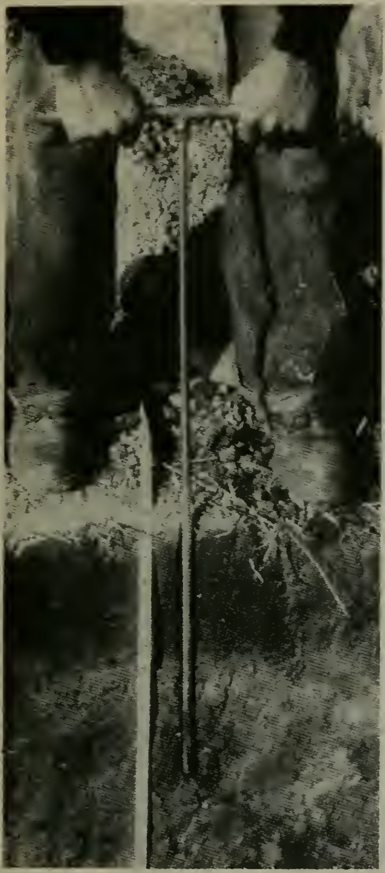


Figure 24.—*Using T-square probe.*

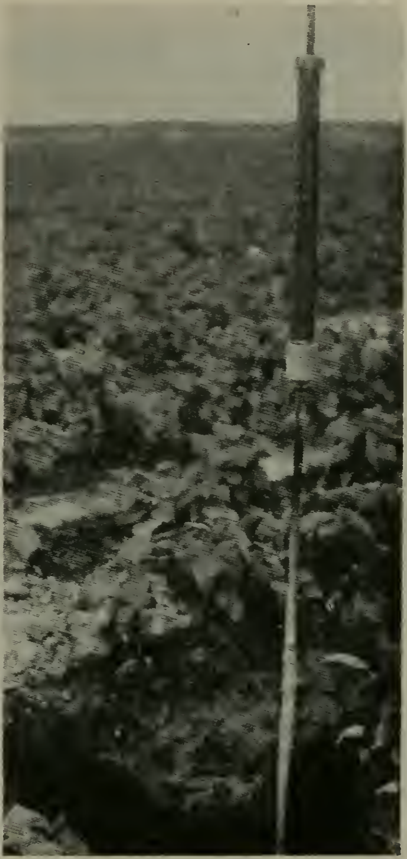


Figure 25.—*Using Proctor probe.*

This clay soil was deficient in humus and therefore the soil below the plow slice was also nearly impervious to water, air, and plant roots.

In this cross section of clay very few roots had penetrated the plow sole. Here was real need for deep-rooted plants like alfalfa or sweetclover, which break through and open it.

In checking the moisture content of a field of beans the farmer used a Proctor tester (fig. 25) instead of the T-handle on his probe. A

Proctor probe shows the pounds of pressure necessary to penetrate different soil types with various amounts of moisture. The **T**-handle probe is usually all that the farmer needs.

The farmer in this picture tested both the center of the water-bearing furrow and the centers of the bean rows on both sides of it. He then turned the water into the adjoining furrows and dug a hole. He was a careful irrigator and wanted to verify the findings.

When first using a moisture probe take a few minutes to dig down to see why it goes down more easily in one spot than another and why it stops. You will soon be able to calibrate your sense of touch with actual conditions.

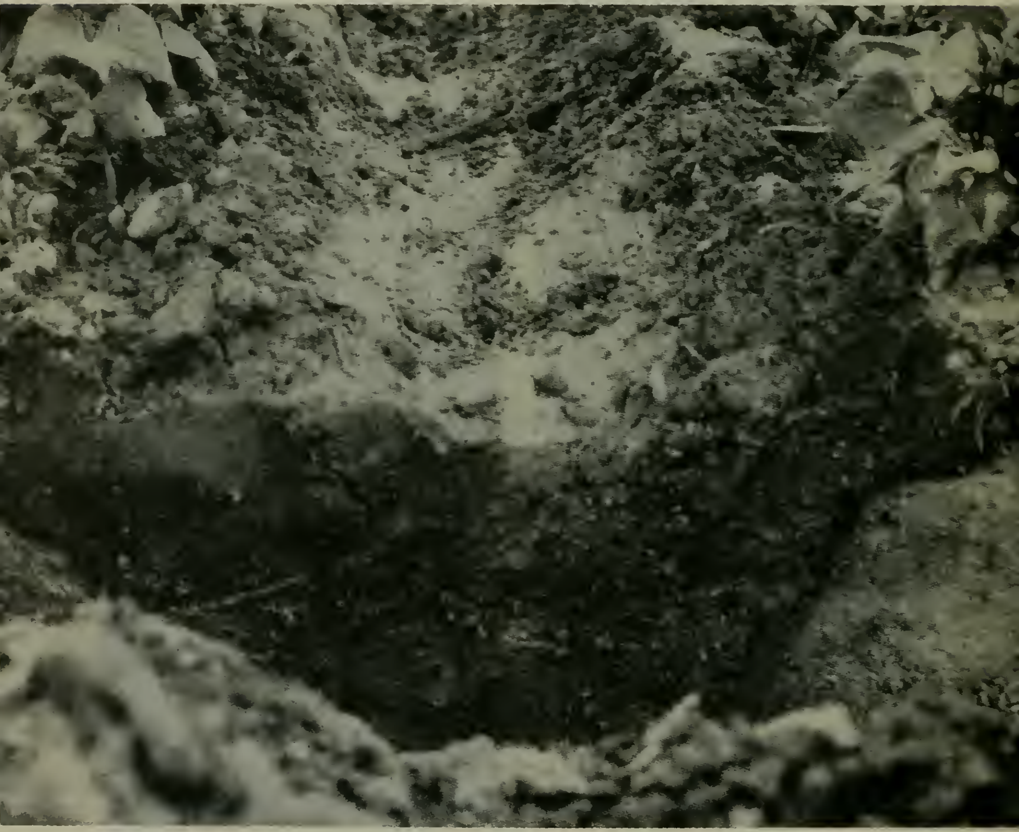


Figure 26.—*Moisture penetration—excavated cross section of soil.*

Figure 26 shows a soil cross section of the hole the farmer dug in his bean field. The water had saturated the soil in an irregular bow shape (the dark portion) about 20 inches below the bottom of the furrow.

Even though this farm was a new homestead and had been plowed only twice, a light plow sole had already been formed. But this farm's sandy soil made the formation of this light plow sole actually desirable, because it helped the lateral spread of the water. Without it, the water would have sunk too fast and not widely enough. But, this particular plow sole, it should be emphasized, proved beneficial only because it was not heavy and compact enough to prevent root penetration.

Roots of the bean plants are visible at the extreme right in the plow slice.

In addition to calibrating the sense of touch when probing and excavating a cross section, the farmer can further verify his findings by examining the soil.

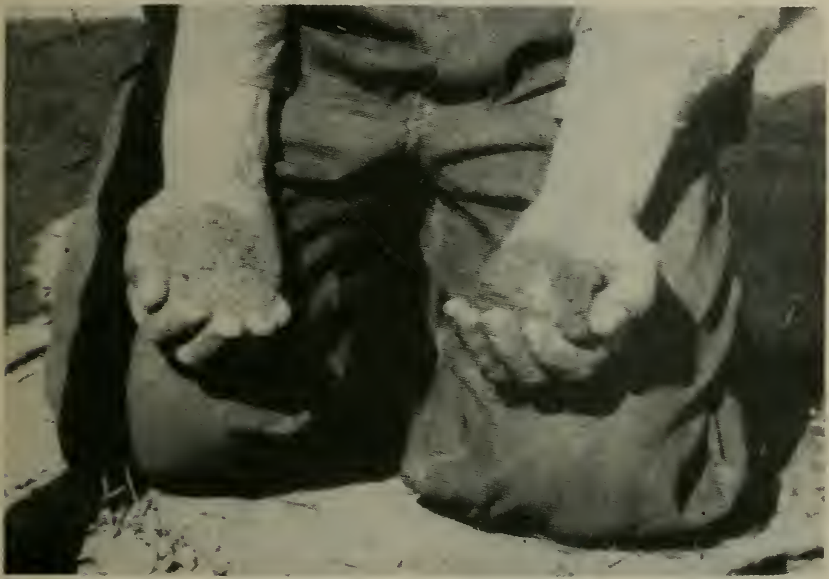


Figure 27.—*Dry soil—damp soil.*

This farmer's hands in figure 27 hold soil taken from an excavated cross section. His right hand holds light, dry soil taken from the layer where the probe had stopped. His left hand holds dark, moist soil taken from the layers that were penetrated. From the feel he can tell that the light-colored dry soil in his right hand would not sustain plant growth.

Judging whether or not the soil contains the right amount of moisture for plant growth by handling or compressing it in the hand is a quick, simple test. If the soil holds its shape when compressed, the plants are surely not suffering from lack of moisture. It is a prime example of the practical use of that sense of touch or feeling with which most farmers are familiar.

2. Requirements of Certain Plants.

Farmers who wish to irrigate wisely realize that if they want to give their crops the right amount of water they ought to know the approximate location of the roots, both in depth and spread.

Figure 28 shows a typical potato plant root system. Note the distribution of potato roots in the different foot depths.

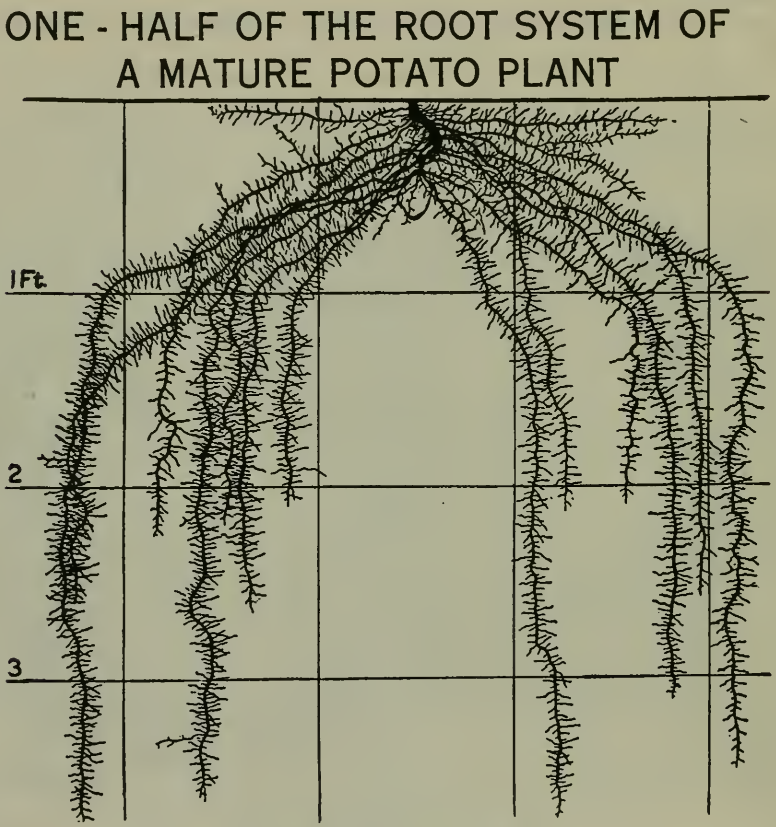
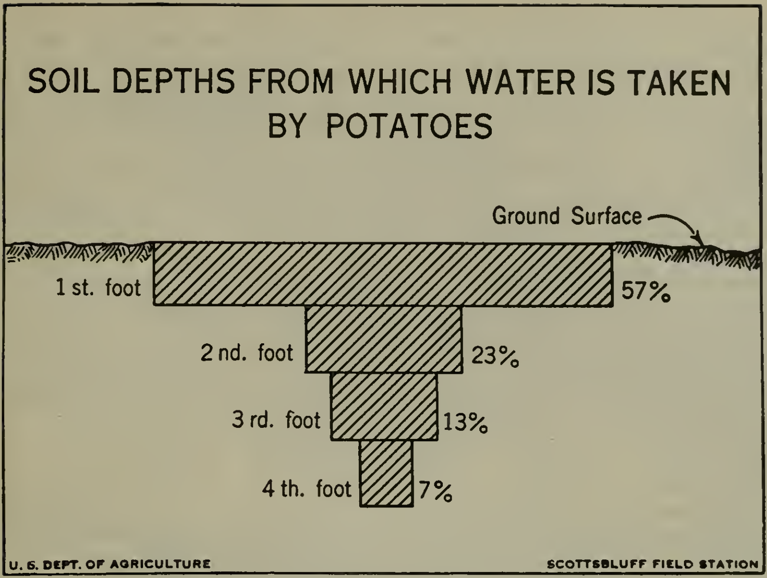


Figure 28.—*Potato roots.*

Soil composition, moisture, climatic conditions, fertility, and other factors can change the root system of any plant, and different varieties of potatoes develop different root systems, but the picture gives a good idea of the potato plant's feeding zone.

Figure 29 clearly shows where potatoes get most of their moisture—57 percent from the top foot of soil and 93 percent altogether from the top 3 feet. Compare the diagram with the picture of the potato-root system in figure 28 immediately preceding. See how they match.

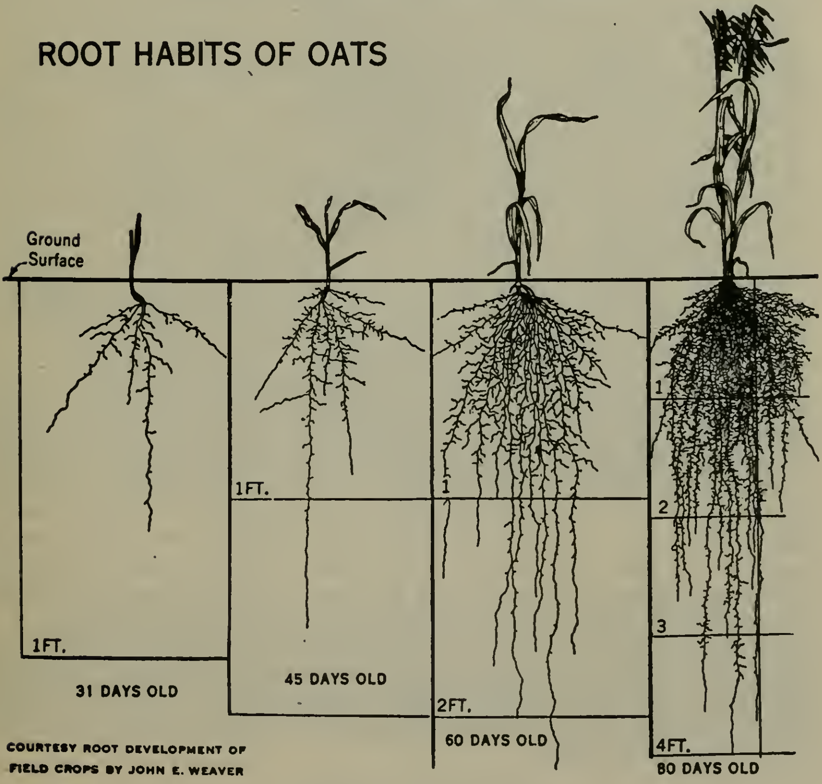
Figure 30 shows a composite view of the oat plant-root system at different stages of growth.



U. S. DEPT. OF AGRICULTURE

SCOTTSBLUFF FIELD STATION

Figure 29.—*Moisture depths—potatoes.*



COURTESY ROOT DEVELOPMENT OF FIELD CROPS BY JOHN E. WEAVER

Figure 30.—*Oat roots.*

In general, the lateral or side roots of a plant will usually take care of themselves (injury from too deep cultivation of row crop excepted) if the perpendicular or tap roots are in healthy growing condition.

The view demonstrates the downward movement of oat roots. With favorable soil conditions they will grow at the rate of nearly half an inch a day.

Irrigate according to the development of the plant. Make allowance for root growth by keeping the soil moistened well ahead of the growing roots.

Remember, the composition of your soil determines its water-storage capacity. Clay soils hold water longer than sandy soils.

Figure 31 shows that in the Scottsbluff experiments oats took 92 percent of their water from the top 3 feet of soil.

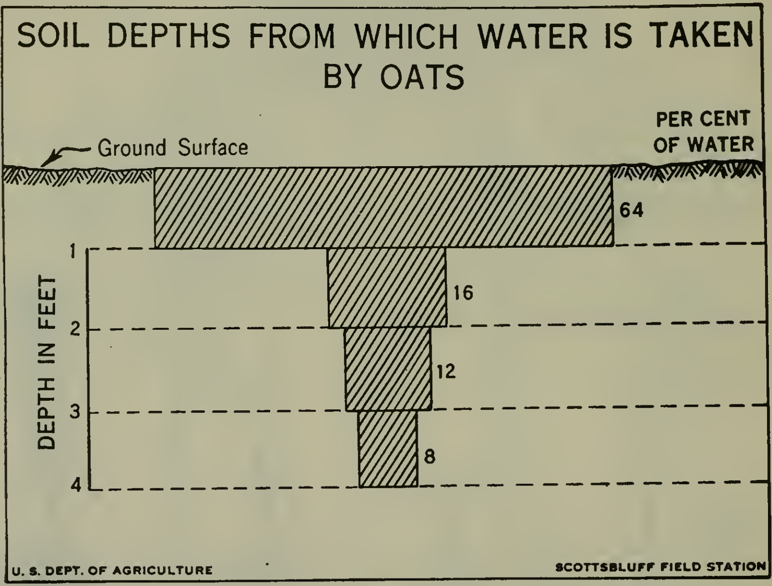
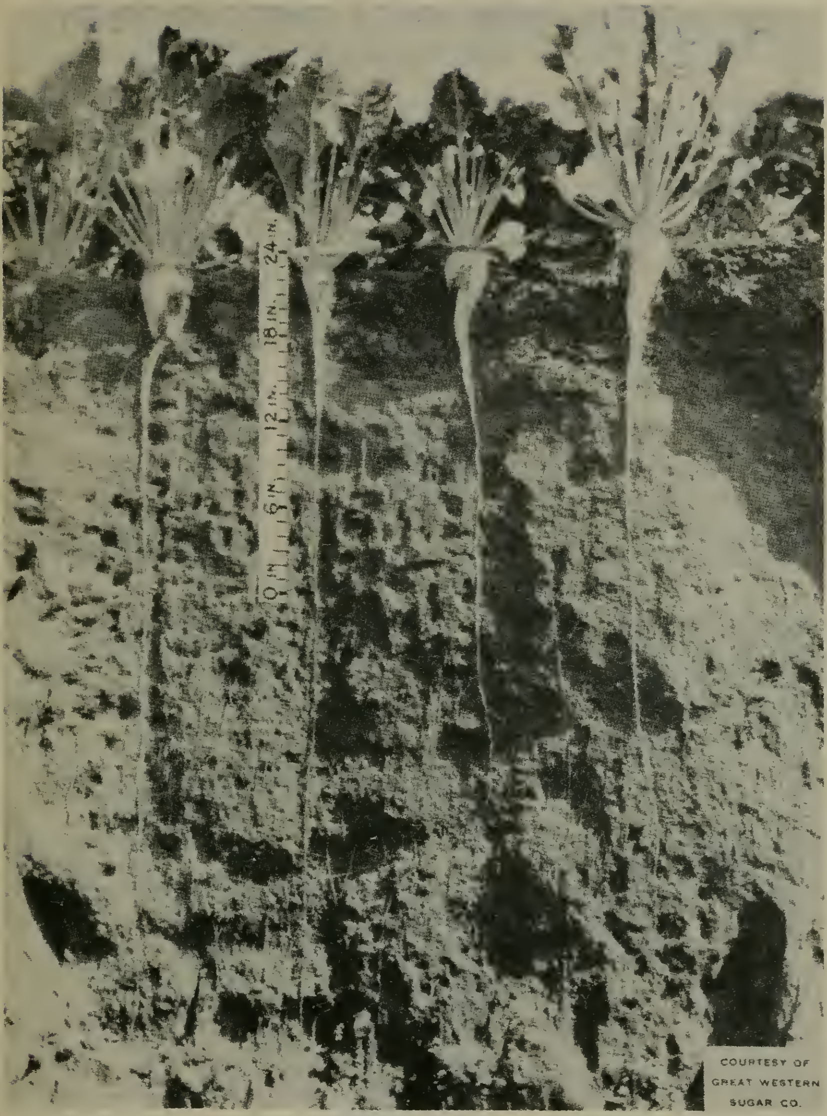


Figure 31.—*Moisture depths—oats.*

Five years of experiments at the Scottsbluff field station in Nebraska under the direction of the late Mr. Leslie Bowen, of the Department of Agriculture, indicated that all crops except alfalfa take 80 to 90 percent of the total water used from the top 3 feet of soil.

With relatively shallow-rooted plants like potatoes, small grain, and sugar beets, it was Mr. Bowen's opinion that filling the top 3 feet of soil with water at each irrigation would supply the plant's water needs at the lower depths also. With deep-rooted plants like alfalfa, he recommended an increase to 4 or 5 feet. He considered it unnecessary to fill the soil to 9 feet, or even 6 feet, as is sometimes done.

The tests also showed that with good soil conditions approximately 13½ acre-inches of water, including rainfall, produced 263 bushels of potatoes to the acre, 14 acre-inches produced 48½ bushels of oats per acre, 24 inches almost 15 tons of sugar beets, and 26 inches a little more than 5 tons of alfalfa.



COURTESY OF GREAT WESTERN SUGAR CO.

Figure 32.—*Sugar beet roots.*

Here in figure 32 is a full-length picture of sugar beet plants.

Opposite the 12-inch mark on the rule appears a change in the soil. If you look closely you can see on the extreme left a layer of soil about half a foot thick. This layer becomes less distinct toward the middle of the picture. It was broken by deep-rooted alfalfa or sweet clover.

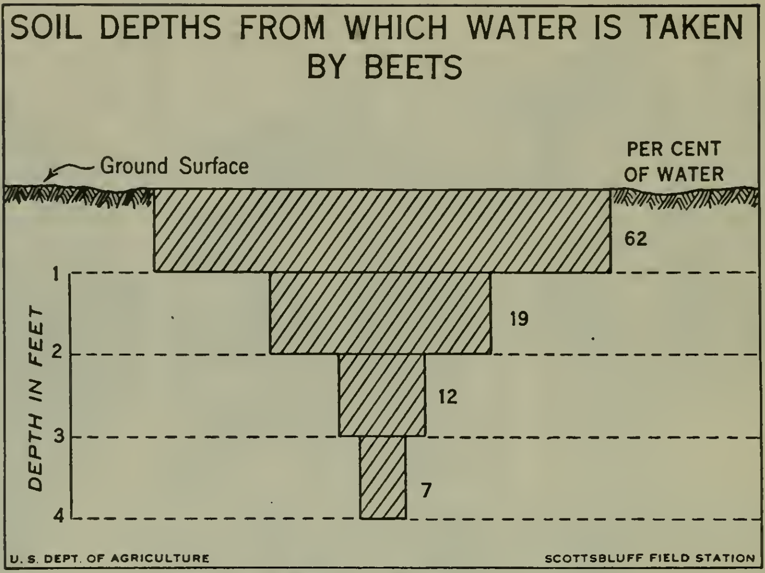


Figure 33.—*Moisture depths—sugar beets.*

Figure 33 shows the soil depths from which water was taken by beets grown in the experiments at the Scottsbluff station.

The experiments made at the Scottsbluff station showed that alfalfa, with its deep roots, takes only 77 percent of its water from the top 3 feet of soil. See figure 34.

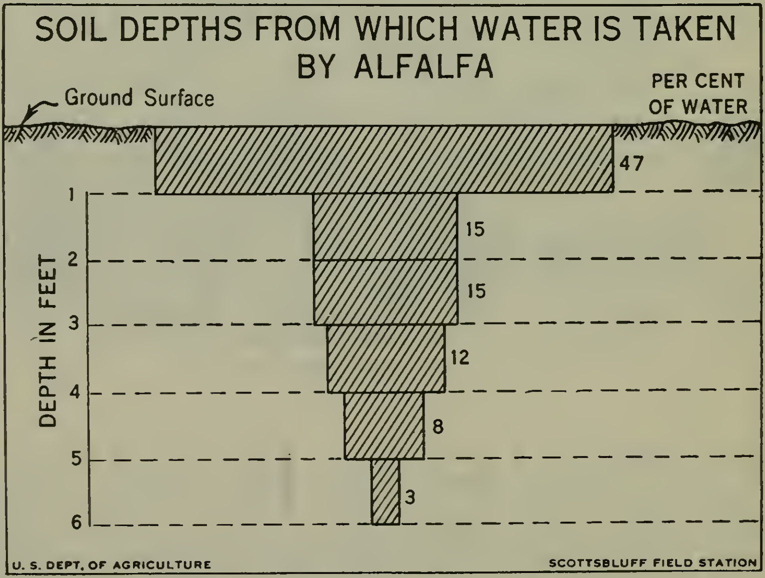


Figure 34.—*Moisture depths—alfalfa.*

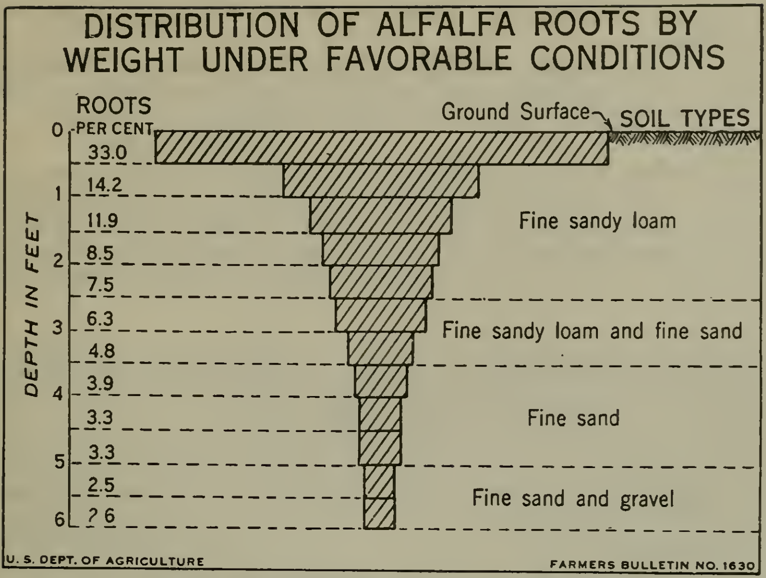


Figure 35.—*Favorable root growth—alfalfa.*

Here in figure 35 you can visualize the penetration of the alfalfa plant root system under favorable soil conditions.

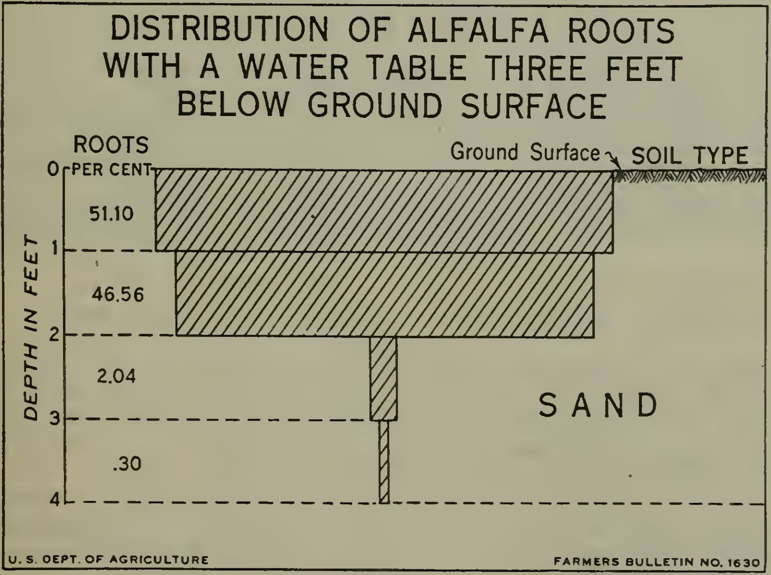


Figure 36.—*Unfavorable root growth—alfalfa.*

Figure 36 shows the distribution of alfalfa roots in soil with a water table 3 feet below the surface. Under such conditions alfalfa yields are bound to be lower than where the water table is 6 or 8 feet below the surface.

When a temporary shortage of water—with enough, however, to maintain plant growth—once lowered the high-water table in a farmer's alfalfa field, he found his yield considerably increased. His shortage of water actually proved to be a blessing in disguise.

Alfalfa has one of the deepest root systems of any plant grown under irrigation and is a heavy user of water, remember, however.

Young bean plants require very little moisture. Their water requirement increases gradually as they grow until it reaches a maximum when the plants are podding and filling. The requirement then tapers off.

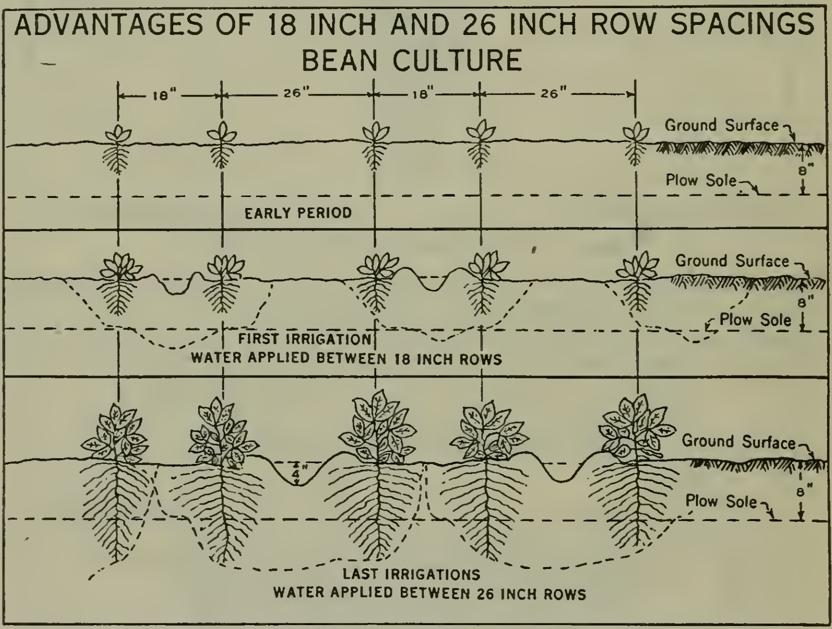


Figure 37.—*Bean plant culture—alternate 18- and 26-inch spacing.*

One way of regulating the flow of water to bean plants is by spacing them in alternate 18- and 26-inch furrows, as in figure 37. The farmer can send the water down the 18-inch row first while the plants are younger and require less water. Later he levels off the 18-inch furrow and diverts the flow to the 26-inch furrow.

This method has an added advantage. Any necessary cultivation can be done between the 26-inch furrows within a few days after irrigating the 18-inch furrows. The water from the 18-inch furrows does not spread to the center portion of the 26-inch furrow.

Also, when the plants are young, the furrows between the 18-inch rows can be made without disturbing the roots. In later cultivation the earth is worked between the 26-inch rows and no further work is done between the 18-inch rows. No roots at any time are disturbed by the cultivator.

Experience shows that many bean farmers have a tendency to stop irrigating too soon. Give your bean crop water up to as near harvest time as possible. It adds weight to the crop and makes the pod easier to open when threshing.

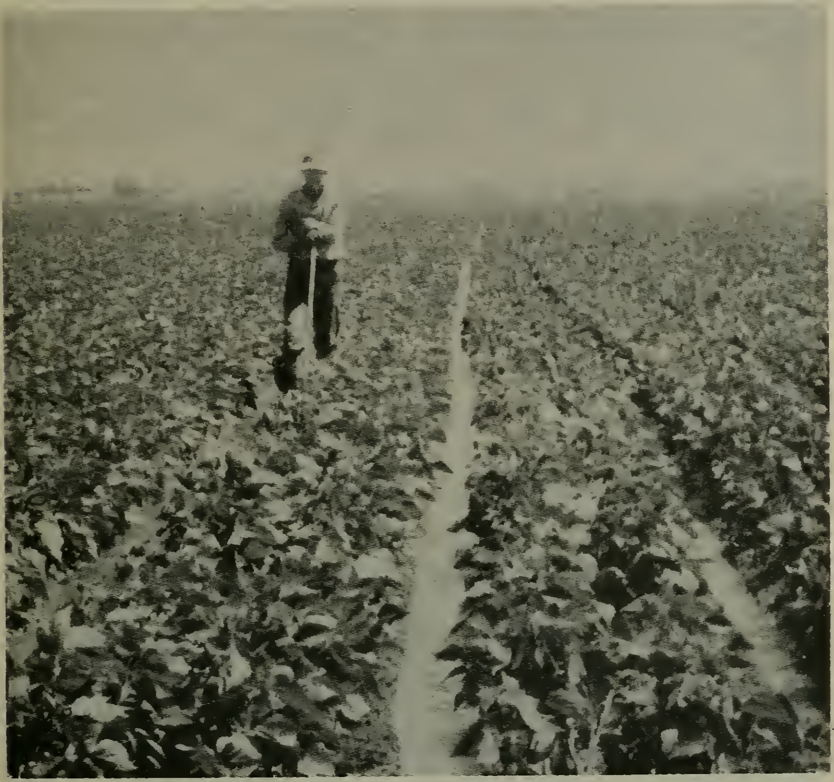


Figure 38.—*Irrigating beans. Water flowing into 26-inch furrows.*

The farmer in figure 38 is observing both surface and subsoil conditions of his bean field as he irrigates.

He has a shovel to regulate the water and to test the soil moisture. A shovel makes a very poor moisture probe, but it is better than guessing.

And down the field in this picture you can see an off-set in the furrows. This is caused by a secondary head ditch which irrigates the next section of furrows.

This farmer—trying to give his bean crop the right amount of water, not soaking wet or almost dry, but just fairly moist from seeding until the crop has reached the peak of growth—planted his beans in the alternate 18- and 26-inch furrows discussed on the preceding page.

He is now running water along the 26-inch furrows.

V. BUILDING UP YOUR SOIL

You have read about irrigation, overirrigation, and its controls. You have also learned how to determine the moisture present in the soil and the different requirements of certain plants. But do not forget that water moisture is only one of the essentials for plant growth. The soil must contain the necessary organic and inorganic food elements also. Without them all the irrigation in the world will not grow an inch of plant life. When they are lacking or deficient, the farmer must add them. Where crop yields are not holding up, the soil needs plant food.

Generally speaking, virgin soils of the arid West are low in humus and nitrates. Soils that have been irrigated and farmed for years may also need soil building. Farming without returning to the soil at least as much plant food as was used by the plants while growing is like drawing checks on a bank account without making further deposits. The notice "Insufficient deposit—Overdrawn" is in the lower crop yield.

From time immemorial green crops have been plowed under to supply nitrogen and needed organic matter. This is a relatively simple and cheap method of increasing soil productivity.

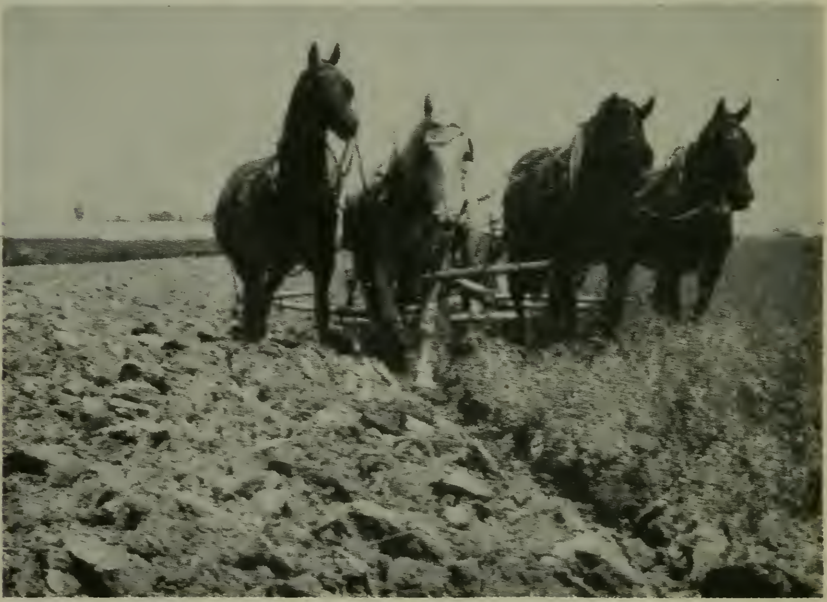


Figure 39.—*Plowing under sweet clover.*

In figure 39 the farmer is plowing under sweet clover to improve his soil by adding nitrogen and organic matter.

Make sure that the soil is damp when you plow under green manure and mulch the ground afterwards. Damp soil makes plowing and harrowing easy and hastens decomposition of the green manure and promotes rapid germination of seed. But the soil should not be wet. Plowing wet soil tends to pack the plow slice and also form a plow sole.

During warm weather green manure decomposes rapidly and proper care should be taken that the plant food liberated by this decomposition is not lost through overirrigation. If too much water goes below the root zone of the plants, leaching may well waste plant food.

The application of barnyard manure to the soil is another of the practical methods of maintaining soil fertility. Unfortunately, few farmers feed all crops grown, and some farmers have only one cow or goat on the farm. But even with livestock farming, providing feed is not brought in from off the farm, there is a drain on the phosphorus supply of the soil. According to Glenn K. Rule, of the Soil Conservation Service, a bushel of oats removes a little over 1 pound of nitrogen, a pound of potash, and about ½ pound of phosphoric acid.

Rotation of crops is also very valuable in improving soil fertility. The proper rotation of crops and the application of commercial fertilizers are especially necessary on farms without livestock.

The old axiom "Feed the plant that feeds you" should be more generally practiced. And in plant feeding, as in livestock feeding, it is important to know what to feed the plant for highest quality and maximum yields.

PLANT FOOD REMOVED BY CROPS

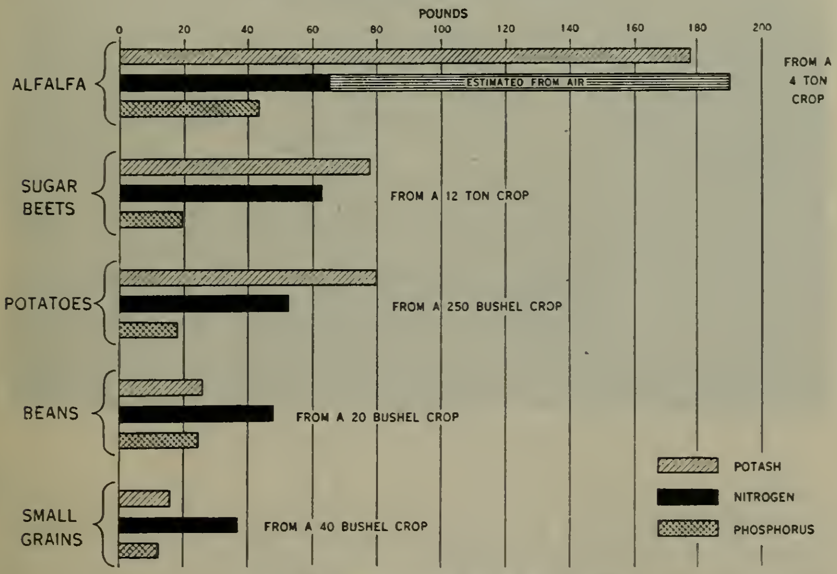


Figure 40.—***Plant food used by crops.***

The chart in figure 40 gives the number of pounds of potash, nitrogen, and phosphorus used by alfalfa, sugar beets, potatoes, beans, and small grains.

Other plant food elements required by crops are carbon, sulphur, calcium, iron, and magnesium.

Lime or calcium is required as a soil amendment or soil stimulant. It conditions the root membranes of plants so that they can absorb plant foods during the entire growing period. Lime is also valuable for its beneficial effect on acid and heavy-textured soils.

Iodine, which is valuable for its effect on man and animals, is another soil constituent required by plants.

Iodine, nitrogen, lime, and some other soil constituents are easily lost by leaching.

A cover crop turned under forms organic acids or other compounds which aid in the liberation of mineral plant food, the United States Department of Agriculture has found. It improves the structure of both heavy and light soils and increases the water-absorbing capacity and the rate of infiltration of water into the soil.

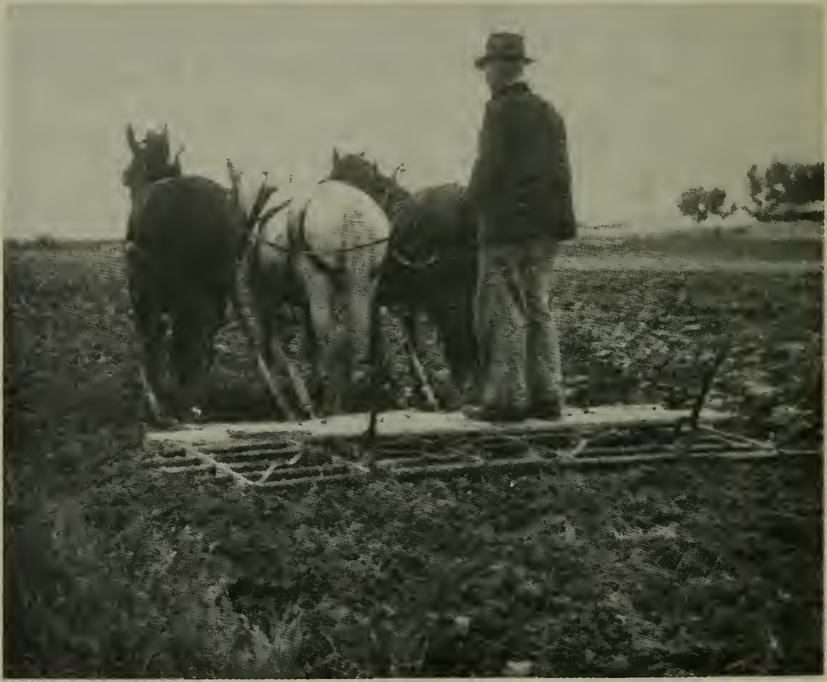


Figure 41.—*Harrowing oats, after plowing under.*

After plowing under a cover crop of oats, the farmer in figure 41 is working down the soil with a spiked tooth harrow. When plowing under green manure the newly plowed soil, especially if clay, should be worked within 4 to 8 hours. This prevents soil baking and loss of moisture by evaporation.

It is possible to obtain a cash crop from the land and still build up your soil in the same season. Where seasons are comparatively long you can plant biennial sweetclover, for instance, with your cash crop. Where they are short you can use Hubam clover, an annual. Planted with early grain or peas and given continued proper irrigation and care, Hubam clover will supply ample green foliage to plow under within 4 weeks after the cash crop has been harvested.

Hubam makes a slow growth above the ground during the early stages of growth when the root system is being formed, a factor in its favor because the grain is less affected. It also offers no trouble from young plants of clover coming up from seed or from year-old plants the following season when row crops are planted.

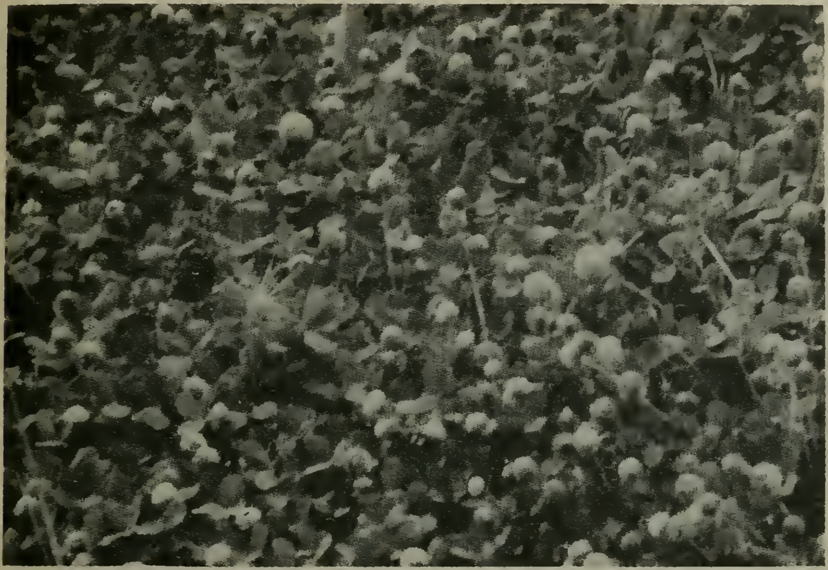


Figure 42.—*Strawberry clover.*

Figure 42 pictures strawberry clover, a perennial leguminous pasture plant which is being tried on many irrigated projects for seeped areas too wet for other plants to grow. These plants have spread strawberry-fashion at the root nodes. Their runners entirely cover the ground.

The blossoms, seed, and leaves of strawberry clover are practically all livestock can reach when grazing. Its runners, which are comparable to the stems of alfalfa, hug the ground closely. Strawberry clover is therefore unlikely to get too coarse for grazing.

Strawberry clover is especially suited to wet, alkaline ground. It likes wet "feet" and is tolerant of alkali. It also makes a splendid permanent pasture on well-drained, well-irrigated land.

Pastures should not be overlooked if you are trying to build up the soil of your farm. They can serve a double purpose—furnish feed for livestock and at the same time improve the soil, especially with leguminous crops such as alfalfa, sweetclover, and strawberry clover.

After reading about strawberry clover in his local newspaper the owner of a farm on a Nebraska project realized that this was the plant which covered his pasture pictured in figure 43, so highly relished by his stock. The land had been seeded to a tame pasture with imported seed some 15 years before. The seed had undoubtedly contained some strawberry clover. More aggressive and at home on seeped land the strawberry clover in due time ran out all other plants, including the weeds.

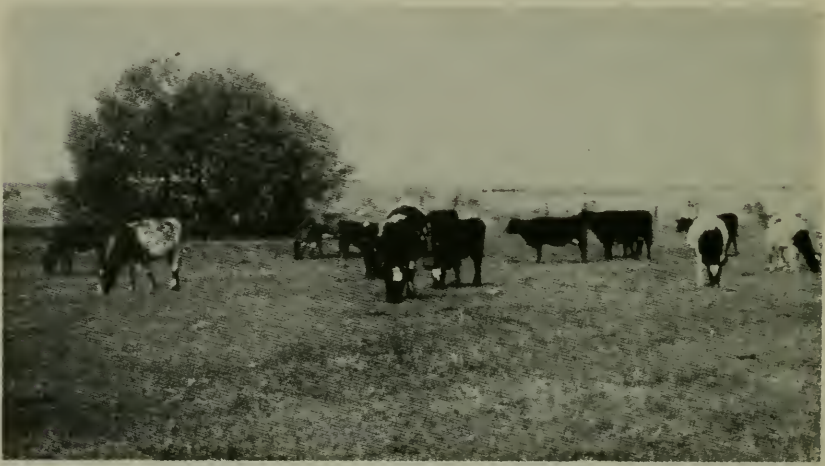


Figure 43.—***Pasture of strawberry clover.***

This 10-acre pasture carried an average of 37 head of cattle for a period of about 150 days in 1937. The cattle made satisfactory growth and there were no cases of bloat. The following year it carried the stock until June, after which the farmer fenced off 8 of the 10 acres for seed and pastured 6 cows, 4 calves, and 3 work horses until the middle of September.

This farmer is building up his soil both through his livestock and the leguminous strawberry clover.

VI. ANCHORING YOUR SOIL

After taking the time and expense of improving your soil by adding organic matter and fertilizers to the plow slice, it is only good business to prevent the wind from blowing away this fertile topsoil. Trees for windbreaks and strip farming help, and listing the soil like this farmer in figure 44 is also effective. After harvesting his crops he is running off ridges at right angles to the prevailing winds. If and when the winds level the field down to the point where erosion appears imminent, he will list the soil again.

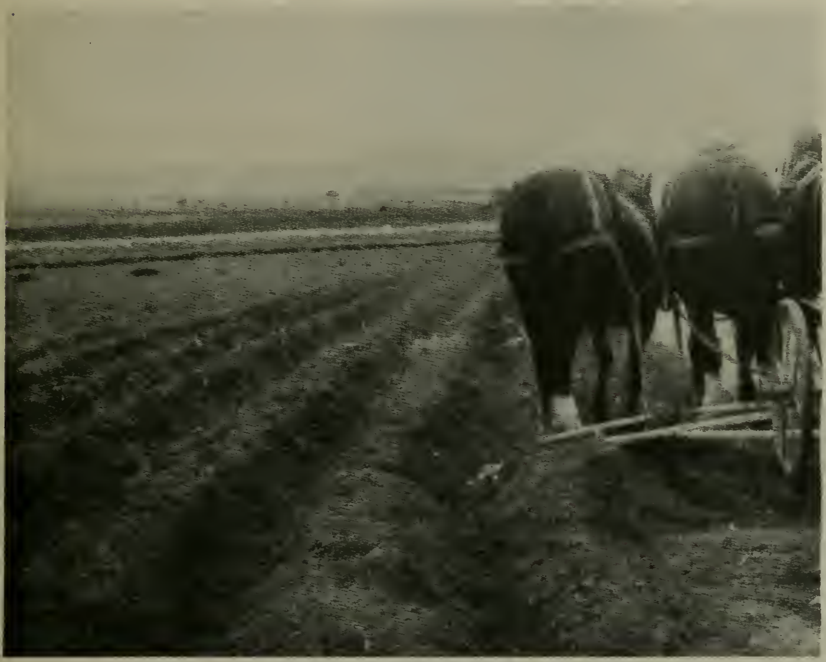


Figure 44.—***Listing the soil to prevent wind erosion.***

Where grain or alfalfa is seeded in windy areas, the corrugation system—if you can use it—will also provide a rough field surface to lessen wind erosion.

VII. EXPERIMENTING

Every farm should have its own experiment station. Every farmer should have a small plot of land on which to try out in a small way the application of green or barnyard manures and commercial fertilizers or combinations of these to learn if they increase his crop returns. It pays.

If you use a commercial fertilizer, be sure to learn what plant foods it contains. Look for a statement of the composition of the fertilizer on the sack or container.

Here in figure 45 is the experimental plot of a practical farmer on a project in Colorado. To find out if commercial fertilizer would help, he applied superphosphate in strips at the rate of 150 pounds per acre.

You see this farmer with his right foot on the phosphated strip of alfalfa and his left foot on the nonfertilized strip. Compare the difference in the height and foliage of these two plots. The phosphated alfalfa comes right up to his knee, the other only halfway.

This farmer estimates that the fertilized strip produced three or four times as much hay. He also found that the fertilized alfalfa was healthier, had superior color, stooled out better, and made a heavier growth during the entire season.

Do not infer from this that when yields of alfalfa are poor the soil merely needs superphosphate or some other commercial fertilizer. Large quantities of commercial fertilizer may be applied without any appreciable effects upon the yield or quality of crops if the soil is deficient in organic matter or because of some other factor.

The facts you learn from experimenting on a small plot on your farm with different soil-building practices will guide you far more effectively in determining the right treatment for your soils than any rigid set of formulae.

Soils are different. You are the doctor to the soil on your farm. Learn what your own particular soil—your patient—needs to keep it healthy. Be wise, and while you may not also become wealthy you will at least become the richer by good, fine crops.

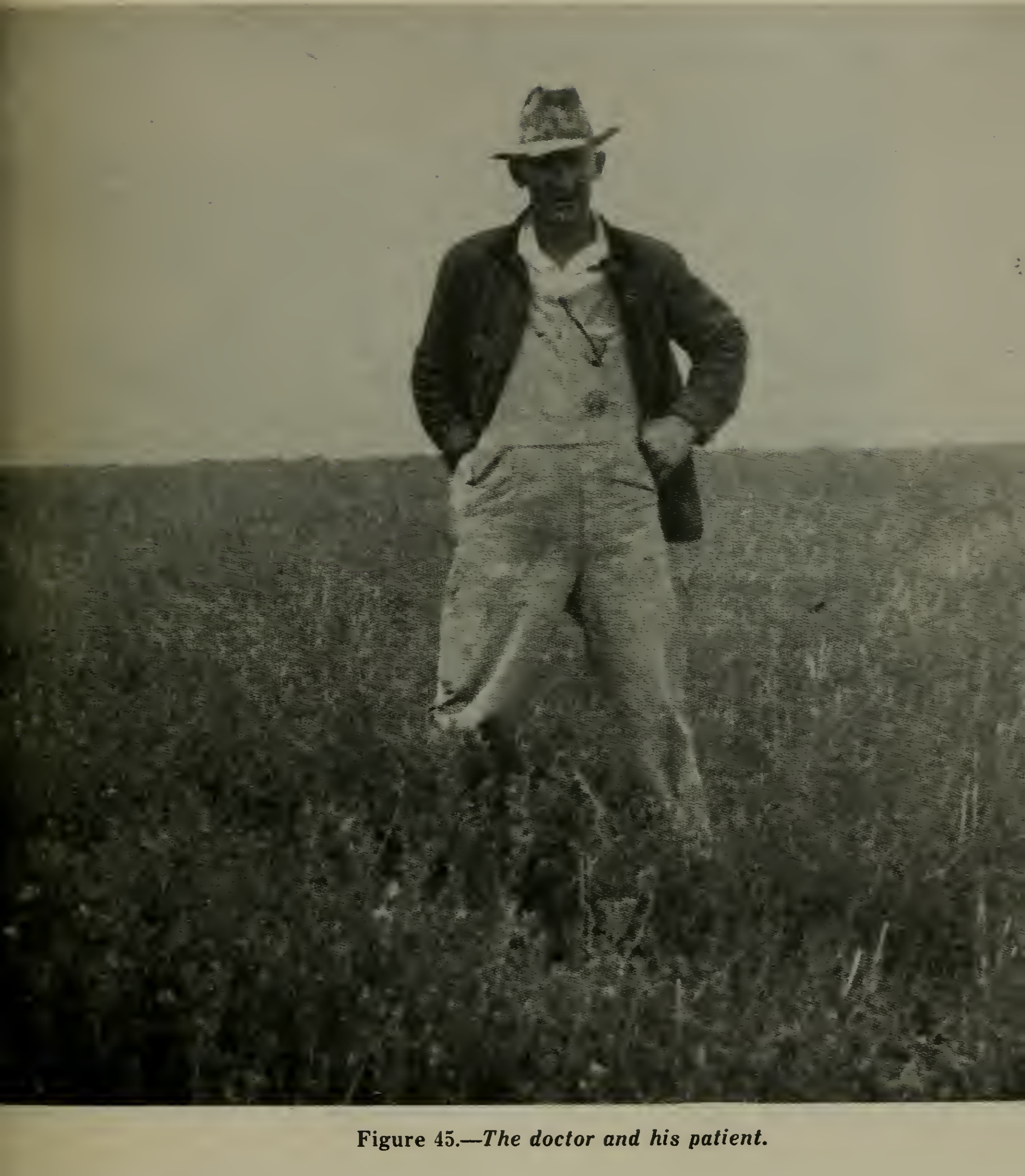


Figure 45.—*The doctor and his patient.*

FOLLOW THESE EIGHT RULES

1. Get acquainted with the subsurface of your farm.
2. Grade the ground except where too close to sand and gravel or hardpan.
3. Replace plant food removed with the topsoil by the grading.
4. Irrigate your crop—don't drown it. Control the water flow—don't leach or erode your soil.
5. Watch your soil. It is the reservoir which holds the water for plant roots from one irrigation to another. Guessing when it is empty, partly filled or running over will cut your yield. Keep the root zone moist—not soaking wet or almost dry. Eliminate the guesswork and use a moisture probe.
6. Farm your field so as to build up and improve your soil. Grow leguminous crops. Plow under. Rotate your crops.
7. Anchor your soil if your farm is in a windy area. Don't let it blow away.
8. Finally, do not hesitate to experiment. Set aside a small plot and try different fertilizers and amounts of water on it. *It pays.*

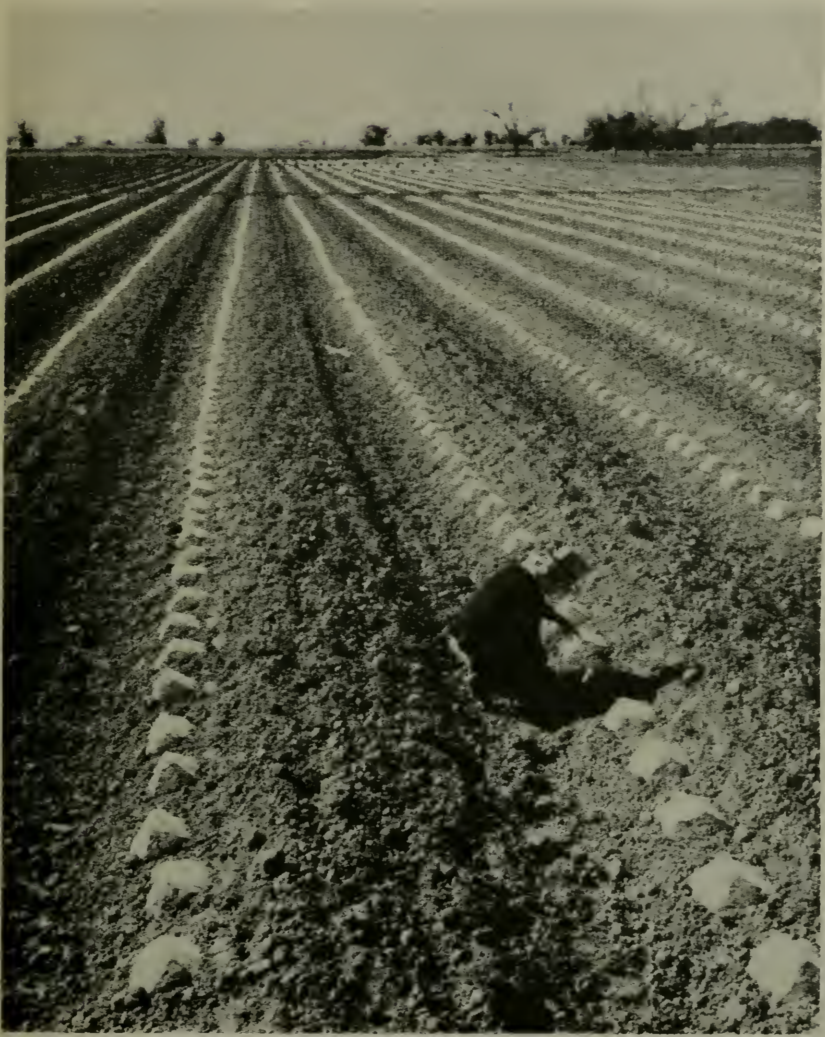


Figure 46.—*Melons under irrigation in the Southwest.*